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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

MEETING OF THE SUBCOMMITTEE ON

THERMAL-HYDRAULIC PHENOMENA

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TUESDAY,

JULY 8, 2003

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The meeting was convened in Room T-2B3 of Two White Flint North, 11545 Rockville Pike, Rockville, Maryland, at 8:30 a.m., Dr. Graham B. Wallis, Chairman, presiding.

COMMITTEE MEMBERS:

GRAHAM B. WALLIS, Chairman
F. PETER FORD, Member
THOMAS S. KRESS, Member
DANA A. POWERS, Member
VICTOR H. RANSOM, Member
JOHN D. SIEBER, Member

ACRS STAFF PRESENT:

RALPH CARUSO, ACRS Staff, Designated Government Official

SANJOY BANERJEE, ACRS Consultant

VIRGIL E. SCHROCK, ACRS Consultant

ALSO PRESENT:

YEE K. CHEUNG, General Electric

ROBERT GAMBLE, General Electric

ATAMBIR RAO, General Electric

BHARAT SHIRALKAR, General Electric

PATRICK BARANOSWSKY, RES

AMY CUBBAGE, NRR/DRIP/NRL

JAMES HAN, RES/DSARE/SMSAB

DON HELTON, RES/DSARE/SMSAB

JOHN V. KAUFFMAN, RES/DSARE/REAHFB

WILLIAM KROTIUK, RES/DSARE/SMSAB

RALPH LANDRY, NRR/DSSA/SRXB

SHANLAI LU, NRR/DSSA/SRXB

MUHHAMAD M. RAZZAQUE, NRR/SRXB

JACK ROSENTHAL, RES

JOSEPH STAUDEMEIER, RES/DSARE/SMSAB

GEORGE THOMAS, NRR/DSSA/SRXB

EDWARD D. THROM, NRR/DSSA/SPSB

JERRY WILSON, NRR/DRIP

MARCOS ORTIZ, ISL

C-O-N-T-E-N-T-S

P-R-O-C-E-E-D-I-N-G-S

(8:31 a.m.)

CHAIRMAN WALLIS: This is a meeting of the Advisory Committee on Reactor Safeguards, Subcommittee on Thermal Hydraulic Phenomena.

I'm Graham Wallis, the Chairman of the Subcommittee. Subcommittee members in attendance are Tom Kress, Victor Ransom, Peter Ford and Dana Powers, and I think Jack Sieber may come, too.

Consultants in attendance are Sanjoy Banerjee and Virgil Schrock.

The purpose of this meeting is to discuss the application of the TRACG code to the economic and simplified boiling water reactor, ESBWR -- at last we know what its name is -- and the ESBWR scaling analysis.

The Subcommittee will hold discussions with representatives of the NRC staff, General Electric Nuclear Energy, and other interested persons regarding this measure. The Subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions as appropriate for deliberation by the full Committee.

Ralph Caruso is the Designated Federal Official for this meeting.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register on June 25th, 2003.

Portions of this meeting will be closed for the discussion of proprietary information.

A transcript is being kept and will be made available as stated in the Federal Register notice. It is requested that speakers first identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

We have not received any requests from members of the public to make oral statements or written comments.

We will now proceed with the meeting, and I call upon Ms. Amy Cubbage of the Office of Nuclear Regulation to begin, please.

MR. CARUSO: One more comment. Dr. Peter Ford.

MEMBER FORD: I have a conflict of interest since I'm a G.E. retiree.

CHAIRMAN WALLIS: Okay. Thank you.

MR. CARUSO: Amy.

MS. CUBBAGE: Thank you.

On behalf of the staff, late this

afternoon we'll be making presentations to the Committee. This morning we're going to begin with General Electric. Mr. Atam Rao is the project manager for the ESBWR project. He'll be providing an overview of the project.

CHAIRMAN WALLIS: Atam, it's always a pleasure to hear from you, and I'm glad we finally got you here to talk about this impressive machine of yours.

MR. RAO: Thank you for giving us the time.

We wanted to give you an update on where the design is and where the technology closure is going on this project.

One of our objectives of this pre-application review is shown in Chart No. 3, and I'll get to that, and that is to obtain closure on the technology program that's been ongoing for the last 15 years. I'll give you an overview of the design and the program. I'll give you an overview of the submittals we've made since I made a brief presentation to the ACRS last year and summarize where we are going in the overall project.

I know you had mentioned that you're glad that we finally announced what the ESB stands for. We were waiting for a utility, Entergy or Excelon, so that we'd name the E after them, but I guess that hasn't happened yet. The E stands for economic. We finally decided that in the early part of this year the --

CHAIRMAN WALLIS: Are you going to demonstrate that this is economic for us?

MR. RAO: Not for you.

(Laughter.)

MR. RAO: We save that for the utilities. We focused on the safety part. That's what the S stands for. The middle initial was S, safety.

Okay. No, simplified, and that --

MR. SCHROCK: Was it formerly something else, Atam?

MR. RAO: Pardon?

MR. SCHROCK: Was it some other name previously?

MR. RAO: There has been a lot of confusion on what the E stood for. It might have been European in the earlier days when we started off about ten or 11 years ago.

CHAIRMAN WALLIS: It's not "excellent," is it?

MR. RAO: Even simpler than the SBWR, ES.

Okay.

(Laughter.)

MR. RAO: The goals for the technology closure are listed out here. Basically two basic goals that we have for the technology closure program. One is approval of the TRACG code for analysis, and the second is confirmation of the adequacy of TRACG.

Let me just describe what those two goals mean specifically. Basically we're looking for the approval of TRACG for the vessel response to pipe breaks, which is the loss of coolant accident, sometimes called the DBA and sometimes called ECCS/LOCA.

I wanted to put down the definition of terms here because we'll be using that in the presentations all the way through. So ECCS/LOCA refers to the vessel response to the pipe break. That's what you will be hearing in all of the different presentations.

And the containment response to the pipe break will be referred to as containment/LOCA, and then we'll be talking about the vessel response to anticipated operational occurrences, sometimes called transience. People will be using that terminology interchangeable, and sometimes it's called AOO.

The fourth one, which is the plant response to ATWS and normal operation stability is not currently part of the technology program and we will be coming back shortly on that. It was more a question of time rather than that this is not what -- it had nothing to do with the adequacy of the TRAC code or whatever. It was just --

CHAIRMAN WALLIS: There are still some very interesting issues for us, I think, those two.

MR. RAO: Yes, but we just ran short of time. What the overall goal here is to show that. I'll come back in the take-away at the end.

The second major goal, which is actually a subpart of the approval of the TRACG code is a confirmation of the adequacy of TRACG, which means that the qualification base that we're taking is adequate. We've done enough testing. There's enough qualification of the uncertainties and all of those issues that go into the qualification of TRACG.

So as I started off earlier, what we've done here is a 15-year plus year comprehensive technology program, and it's using essentially the same thermal hydraulic technology that is used in most BWRs, and is that enough?

And it is an important question because

ultimately I wasn't going to talk about economics or all the rest of it; ultimately industry has to know whether or not we have done enough and whether we need to spend more money, and the sponsors will view that as incomplete if we don't get closure on some of these issues, and that there's no way to get closure.

So that's why we've coined the term "technology closure." The official terminology is pre-application review.

This goes into a little bit more detail on what the steps are for the technology closure plan. Basically we're looking for safety evaluation report for the TRACG application for ECCS/LOCA, the same for containment/LOCA, and for application for AOOs. That's in the first phase of the technology closure program.

That would be based on the different submittals that have been made. The TAPD is the technology and analysis program description. That gives the road map for what has been done, what are the important parameters, what qualification is needed for those important parameters, and the different phases of the transience.

You will hear a detailed presentation by Dr. Shiralkar on that. So one --

CHAIRMAN WALLIS: Let me interject here. I mean, you've got four approvals of application of TRACG for something.

MR. RAO: Right.

CHAIRMAN WALLIS: So we're back to where we usually are with these codes. We know the codes have assumptions and shortcuts and so on in them, and yet they get approved for a particular application rather than sort of approving the code as being perfect in itself, which it never is.

MR. RAO: Right.

CHAIRMAN WALLIS: The approach always is to look at how it compares with data for a particular application; say for that application it's okay.

MR. RAO: Right.

CHAIRMAN WALLIS: That's where we usually are. I'm just sort of reiterating where we are. We always find ourselves with codes when we sort of approve them for applications rather than some generic way.

MR. RAO: That's what we're asking for, for a specific application.

CHAIRMAN WALLIS: In a way, this is a way of getting around what we might say were not necessarily shortcomings, but shortcuts in the code by just looking at the specific applications. So we never face up to going back to the code and saying, "Let's fix the whole thing so we don't have to keep looking at application."

MR. RAO: And the TRACG application for ATWS, we have not yet submitted an application methodology. That's why it's too early to ask for the approval of that.

And for stability, we were going to use ODYSY as the basis for the evaluations there and some TRACG calculations. Again, we haven't submitted the application methodology for that. So we will come back and be working with the staff to define a schedule for doing that.

So this gives the overall picture for what are the -- oops. I keep pressing the wrong buttons.

MR. SCHROCK: Your statement about LOCA is kind of general, and don't you distinguish between the large break LOCA and the small break LOCAs?

MR. RAO: No, we don't.

MR. SCHROCK: In what you're doing to improve the technology?

As I read some of the reports I had the impression that the large break LOCA was being claimed to be covered by previous technology, nothing new to deal with as a result of the design of ESBWR. Is that wrong?

MR. RAO: No, that's not true.

MR. SCHROCK: Okay.

MR. RAO: What we're saying, the first one, ECCS/LOCA or containment/LOCA covers the full spectrum of break sizes. Okay? So we are covering small to large break. There may be some --

MR. SCHROCK: But there is such a statement in the reports that the large break LOCA is basically the same as before.

MR. RAO: I'm not aware of that. There are --

MR. SCHROCK: Well, I'll find it.

MR. RAO: Okay. The ESBWR is basically an evolution within a small range which basically minimizes operational risks. What you'll see is there's been just -- you know, when you go back to the earlier plant designs, they were almost in the 3,300 megawatt range, and the ESBWR is up to 4,000 megawatts thermal.

There's not a huge increase in the range of power that we have a lot of years of experience. We don't want to lose the 40, 50 years of experience with BWRs that we've had over the last 40 or 50 years.

Even the component sizes aren't that much larger. What you see is it's the same vessel diameter as the ABWR, 7.1 meters. In fact, that's how we sort of set the power level. We said we'd keep the same vessel diameter and see what's the maximum power we can get from it.

CHAIRMAN WALLIS: Now, do these take account of the recent power uprates, these numbers?

MR. RAO: These do not take account of the recent uprates. These were the original power.

CHAIRMAN WALLIS: Okay. With the power uprate we're already in the range of ESBWR.

MR. RAO: Right. When we look at the power densities and all, the numbers that are shown here are with the original designs. The power uprates, there are some that have gone to 62 kilowatts per liter. Okay?

So this is with the original design. That's where we got the years of experience.

The number of fuel bundles also --

CHAIRMAN WALLIS: Is this the same fuel as --

MR. RAO: Yes.

CHAIRMAN WALLIS: It's the same fuel as you're going to use?

MR. RAO: It's the same standard fuel, except that it's a little bit shorter, three meters compared to 3.7 meters. Otherwise it's the same fuel design.

Again, the concept being that more from an economic and commercialization point of view, you don't want to design a new fuel where you've got to build new factories. People would order a plant one at a time so that we -- we've got to make sure that the first one is economic and you've got the factories in place.

We are not relying on a six pack order to make this commercially viable.

So the power density as you notice out here is in the range of where we've got lots of experience with the power uprates. I think the life service of the BWR-6 is up at what, 62 kilowatts per liter?

No recirculation pumps.

The type of control rod drives, we've gone to the control rod drives that are in the ABWR, the fine motion drive as opposed to the locking piston drives.

This is where the simplification has come about. So what you can see is in the normal operation it's just like a BWR, except that it doesn't have recirculation pumps. Where the simplification has come is in the safety system area. This shows some of the large pumps. We've gotten rid of them. Mostly a few diesel generators. This --

CHAIRMAN WALLIS: Now, in a way you're replaced a pump, which is a mechanical device, by a natural circulation pump driven by a condenser or something. So in a sense it's a pump. It's not with the conventional mechanical moving parts.

MR. RAO: Yes.

CHAIRMAN WALLIS: And it is a functioning pump in a sense.

MR. RAO: In some senses, yes, when I get into those, but this is more from a body count point of view, from the economics. This is all I was going to say about the economics basically. It's shown out here.

One of the interesting things when you see the evolution of designs over a period of time, the core damage frequencies have come down as we went from BWR-4s, 5s.

CHAIRMAN WALLIS: Now, why did they come down?

MR. RAO: They came down because we added more divisions. We went from two divisions to three divisions. This was two divisions. This was two and a half divisions.

CHAIRMAN WALLIS: Divisions?

MR. RAO: Divisions of safety systems.

CHAIRMAN WALLIS: And the redundancies?

MR. RAO: The redundancies. We've added more redundancy. Okay? Now, this is a full three division system, the ABWR. So there's two, two and a half, three -- I'm just giving you sort of a --

CHAIRMAN WALLIS: No, I think it's useful because in a factor of 100, the question is how did you get a factor of 100. You can adjust from these divisions?

MR. RAO: Just from the divisions, and there were other factors that apply into that. One is that we've reduced the number of pipes. The number of large pipes below the core has gone down. Okay? In the ABWR there are no --

CHAIRMAN WALLIS: The fewer things to go wrong. Is that it?

MR. RAO: Redundancy does give you more things that can go wrong. Okay? But what's happened here is we had learned from the PRAs basically. PRAs went into the design of the ABWR. Okay? I think the

BWR-6 was more before the days of the PRA.

MEMBER KRESS: But the dominant sequences in BWR-6 are ATWS and station blackout?

MR. RAO: Station blackout is the dominant sequence in all of them.

MEMBER KRESS: Station blackout is dominant in all of them?

MR. RAO: In all of them, and that's --

MEMBER KRESS: And how does that relate to zero safety diesels?

MR. RAO: Okay. Now what we've done out here, so that's exactly what I was going to explain to you, is when we went to the ESBWR, we've pretty much four times ten to the minus seven is about as low as you're going to get. To just put it in perspective, the vessel rupture is ten times minus eight, okay? So you've reached about as good as you're going to get, and what we've done out here is basically gone in with passive systems which have allowed us to reduce the complexity of the design, and that shows up out here in the safety building volume, which is expressed in units of cubic meters per megawatt electric.

So you've got about half the size. This is the containment and the reactor building and all of those buildings. They're about half the size of the

ABWR and you get about the same core damage frequency.

Okay. So the reason for going with passive systems besides the soft feeling, you know, it's not quantifiable that passive system are better than active systems. I'm not here to tell you that.

CHAIRMAN WALLIS: No, because we thought that for a while. Then we realized that maybe having a pump is forcing water in is better than letting nature do it because letting nature do it depends on your predictions being right about what nature is going to do.

So it's not always clear that passive is better.

MR. RAO: Yeah, we are not advocating one is better than the other. In fact, when you see the design, what you'll see is in the boiling water reactor, direct cycle plant actually, any direct cycle plant, you have lots of pumps. You heard the multiple pump story for the boiling water reactor.

We still retained all of those pumps. All of those systems are still there. So for those who like pumps, the pumps are still there. They are just not safety grade anymore.

So we've got the balance in the design between the passive systems and the active system. I don't know whether I answered your question.

Basically what we've done, I'll show you what we've done in the safety systems is basically simplified them, and that gives about the same core damage frequency. I think the actual number is a little lower, but it's not significant.

CHAIRMAN WALLIS: Probably when we see a number for a reactor that doesn't exist we should always add a factor of something or other to that number of ten to the minus seven.

MR. RAO: Well, yes and no, but you've got to look at, you know, we're using components that we have good experience with, you know. The main issue really is initiating frequencies, you know, and we have a lot of experience with BWRs, and so we are using the same basic design.

I like to call the ESBWR BWR Lite, same megawatts, just less calories.

We've gone with natural circulation, and basically because it gives us simplification without performance loss. One of the interesting issues in the design of the plant has been people always ask us why did you give up poor circulation.

There are several reasons for doing that. When you combine passive safety systems and natural circulations, for both of those you need a large vessel, and if you get into one or the other, you still retain the larger vessel. So if you put one or the other and you add the second one, you get it for free. Okay?

So we don't have the penalty associated with the large vessel that would come with natural circulation as long as we stay with passive safety systems.

MEMBER SIEBER: So the six meters additional height is just do to provide the driving head?

MR. RAO: That is primarily for the driving head, but as you'll see in the presentation, the basic design of this plant is you put a lot of water in the vessel. The vessel is bigger, and that's your first line of defense. You've got more water in there, and you've actually got more steam in there. So what that does is it makes the loss of coolant accident response a lot better and makes the transient response a lot better because when you get a reactorized solution, since you've got a lot more steam, the pressure goes up at a much slower rate.

And you do need the taller vessel to get the improved natural circulation flow. We get a significant reduction in the components, both pumps, motors, controls, heat exchangers. This is an actual drawing out of the ABWR reactor internal pump system. It's not just pumps. There's a lot of controlled piping and heat exchangers and all of the rest of it. So we got rid of all of that stuff, and we --

MEMBER KRESS: Do your control rods still come in through the bottom?

MR. RAO: The control rods still come in through the bottom. We had looked at other options, and again, we wanted to stay with what was proven and works, and that does work.

And the things that we simplified were basically driven by let's reduce the component count. We'll reduce the material quantities, and --

CHAIRMAN WALLIS: Now, you're reducing the flow resistance in the downcomer.

MR. RAO: Right.

CHAIRMAN WALLIS: In fact, you probably want to reduce a lot of flow resistance. So this looks like something which could have a tendency to oscillate. Natural circulation oscillations occur in many boiler systems and have to be dealt with.

MR. RAO: Right. You've got to take a few things, I remind, just because boilers with pumps and natural circulation oscillate. This is a boiler without pumps.

CHAIRMAN WALLIS: They oscillate more when they're without pumps.

MR. RAO: Which we weren't going to cover that in this presentation, but there's just a little bit out here on the right-hand corner for you to feel comfortable about that. We didn't have a detailed presentation on that. We weren't going to cover it.

CHAIRMAN WALLIS: But you have analyzed the stability. You have analyzed the natural circulation.

MR. RAO: Yes, yes.

MR. SCHROCK: So we don't get to talk about that one today?

MR. RAO: No, stability wasn't on the agenda. We're just going to focus on ECCS/LOCA.

MEMBER KRESS: We'll cover it at some time.

MR. RAO: You'll get a chance, but I don't want to duck the question. Let me just give a one minute answer on that.

What we've done is we've reduce the flow restriction and increased the driving head. We have reduced the restrictions in the separators. We've got a shorter core, reducing the two phase pressure drop, and the biggest improvement is getting rid of the pumps.

You got into an operating BWR and you weld out the pumps, if you want to do that. You would increase the natural circulation flow by a factor of two basically.

This shows the power flow map out here. It's really hard to read out here. We've presented it in the average flow per bundle, average power per bundle rather than the standard power flow mat, and this is what you're concerned about out here. This a jet pump plant. I mean, this is for a BWR-5, the red line. This is for the ABWR, and as you can see out here, in fact, when we went from the jet pump plant to the ABWR, the natural circulation flow actually went down, and that's because the internal pumps provide a major flow restriction in the downcomer out here.

So what we've done in this plant is basically removed that flow restriction. Another way to look at it is what the pump does is it puts in a restriction, and then it has to work and do a lot of extra work to just overcome that initial restriction, and you get only about a 50 percent benefit of that, you know, a little additional extra flow.

So what you see out here is the flow for the ESBWR, and when we look at the power to flow ratio at the 100 percent operation point, it's hard to see all of the detail in that small chart. They are about in the same range as that for a forced circulation plant.

So you've got less power per bundle, and you've got a little less flow per bundle, but the power to flow ratio is about the same range, and you can see we've got about four or five times as much flow compared to the forced circulation plants.

CHAIRMAN WALLIS: Which comes up to the MELLA line on one of those things at the top?

MR. RAO: Right. This is the MELLA line.

CHAIRMAN WALLIS: -- instability in this? You're showing it for the ESBWR.

MR. RAO: Yeah, we've analyzed the stability for the ESBWR. We aren't presenting anything on that today, but the decay ratios are in the range of .2. Okay. So it's much lower than anything, you know.

You've got instability out there, and in this case we are very far away from that point.

MR. CARUSO: Because you're using natural circulation, you're going to have to change your fuel management strategies quite a bit for this reactor, won't you?

MR. RAO: Yeah.

MR. CARUSO: Do you feel confident that the methods will still be valid since you haven't done natural circulation fuel management in 40 years?

MR. RAO: I don't think the fuel management depends on whether you use natural circulation or forced circulation. They just rely on, you know, what are the flow inlets to the bundle. Okay? So, yes, the answer is yes.

DR. BANERJEE: How high is the chimney?

MR. RAO: The chimney is five meters.

PARTICIPANT: Eight, point, five meters.

MR. RAO: Eight, point, five meters.

DR. BANERJEE: So the six meter increase is due to --

MR. RAO: The chimney.

DR. BANERJEE: -- mainly the chimney.

MR. RAO: Mainly the chimney. The core is a meter charter and 8.5 ball park.

DR. BANERJEE: And the chimney you subdivide inside?

MR. RAO: Yeah, it's a meter by meter subchannels.

DR. BANERJEE: So 8.5 meters, meters by meters, and do you have evidence of what goes on in these large --

MR. RAO: Yeah, yeah. In some of the presentations you'll hear where we've qualified the TRACG computer code. In fact, it was done in Ontario Hydro (phonetic). Was it in Montreal or was it Ontario -- I mean Toronto? Somewhere in there. It was actually --

CHAIRMAN WALLIS: Did you look at the flow distribution across the chimney in a 3D sense?

MR. RAO: It's a channel, you know. That's an open --

CHAIRMAN WALLIS: But is that channel so tied to the core so that you can't get a redistribution of flow between channels and the chimney?

MR. RAO: Why don't you save those questions until Bharat?

CHAIRMAN WALLIS: Bharat will explain everything?

MR. RAO: He will give you all, and then when he gets up he'll say that Chester will explain everything and then we'll --

(Laughter.)

CHAIRMAN WALLIS: And we will remember.

DR. BANERJEE: And the velocities are about the same roughly as in a forced circulation plant?

MR. RAO: Yeah. Chester can give you the exact numbers when he comes up. He will give you the exact numbers. I don't remember all of the numbers.

Okay. One of the areas, even though it's a simplified plant, it ends up taking a lot more to explain it, and I am notorious for exceeding my time. So I will try to get through all of the charts here.

One of the ways we got simplification is eliminate systems like you saw in the previous case. We basically got rid of the recirculation system. Another way -- this is just an example -- of where we got simplification was eliminating a total system. We got rid of the shutdown cooling system or the residual heat removal system. There is no RHR system or a separate shutdown cooling system.

What we did in this plant was for normal shutdown -- for accident conditions, there's a separate one and I'll get into that for the safety grade decay heat removal -- but for normal shutdown, there is no RHR system, and we basically combine the reactor water clean-up system. It now has a double function, that it can also operate as a shutdown cooling system.

A really neat innovation out here. This is actually a standard BWR shutdown reactor water clean-up system. Okay? It looks just like that if you go to any of the plants. The only difference, the only two differences are here.

One is in the region rate of heat exchangers. This is how the shutdown cooling system works. It takes suction from the vessel and goes to the regen. heat exchangers, and then it goes to the nonregenerative heat exchangers. Here's a pump. Here is the demineralizers, and it puts the water back into the vessel.

Okay. So what we did on this was it has pumps and heat exchangers. For those of you who like pumps and heat exchangers, they are there, plenty of them.

In a shutdown cooling mode, we basically bypass the regenerative heat exchangers, and we remove the decay heat from using the nonregenerative heat exchangers.

These in a traditional reactor water clean-up system are a little smaller than what will be needed for shutdown cooling. So by increasing the size of these heat exchangers, why, basically increase the area by a factor of four, we have eliminated an entire system, the shutdown cooling system.

So these heat exchangers are a surface area of a factor of four, and actually they don't take up much more space, and we had to make a few changes on the pumps on this side out here.

MEMBER KRESS: And you have to make the pipes bigger also?

MR. RAO: No, the pipes are the same size.

MEMBER KRESS: The pipes are the same size?

MR. RAO: The pipes are the same size. The only other thing that we changed was we put in a second pump because the flow rates are a little different. Okay?

So for the high flow and the low flow conditions. So that's the only additional thing. this pump here, and of course you bypass the filter demineralizers dealing shutdown cooling, and you reduce the number of pipes, the amount of maintenance and all of the rest of it.

And you get an advantage. You get a performance advantage. Now you have a full pressure shutdown cooling system. A traditional boiling water reactor --

MEMBER KRESS: Do you have to manually operate that bypass valves?

MR. RAO: Yeah, yeah. There are two chains of these, by the way.

In a traditional boiling water reactor to get to shutdown cooling, the shutdown cooling system, the RHR system can only operate at about 400 psi or thereabouts. My numbers are going to be approximate. Okay?

This one can kick in at full pressure. So in that sense you've improved the operability and the safety of the design.

DR. BANERJEE: Is this because natural circulation is just easier? What is the qualitative difference --

MR. RAO: Between this plant --

DR. BANERJEE: -- that allows you to do this and --

MR. RAO: Okay. Because --

DR. BANERJEE: -- you can't do it in another plant?

MR. RAO: No. In the active plant, you have to have an active decay heat removal system. So you use that for normal shutdown also. Okay? You use the same system. This is for just normal shutdown. This is when you're going into refueling. Okay?

So you use the same system cool down during a refueling outage. So since you don't have -- passive systems you've got to remember do not get you to ambient conditions. They always keep you at above ambient conditions. Okay? So with a passive system for normal shutdown during refueling, you'd need pumps and heat exchangers to get down to below ambient conditions. So that's the reason you can do this here.

MEMBER FORD: You mentioned earlier on that your pumps were not safety grade. That doesn't apply to these?

MR. RAO: This doesn't apply. This is just for normal shutdown, not for accident conditions.

MR. CARUSO: How long after shutdown are the heat exchangers sized for? I mean decay heat drops versus time. At what point were you planning on this system being able to remove decay heat?

MR. RAO: I don't remember the number offhand.

MR. CARUSO: One hour or 12 hours?

MR. RAO: No, I'm sure it's in the -- I

don't know. We can get back to you on that one. It's fairly because, you know, we're trying to meet some fairly aggressive refueling outage times.

My guess, I would have said one hour, but you know, I don't remember the number offhand.

Did I answer your question, Sanjoy? Yeah?

DR. BANERJEE: Yeah.

MR. RAO: Okay. This is the plant basically.

Let me go back to the previous chart. Just remember the most complicated systems and plants are all of these water systems, you know. Everyone talks about the safety systems, but the water systems have heat exchangers, pumps, controls. They need electrical supplies, and they go all over the plant.

So by eliminating a full water system, you end up with a major simplification. The passive safety system in this plant are basically all shown out here, and this looks like a traditional boiling water reactor vessel. This is the reactor vessel. The control rod drives still come in at the bottom, shown out here.

You've got four steam lines. These are then two steam lines here and two steam lines here. These are the feedwater lines out here.

When we went from the SBWR to the ESBWR, one of the really neat things about a direct cycle plant is we didn't have to to add another set of steam generators to make them bigger. We added two more steam lines. Okay? That's pretty much all that we are doing to add more fuel also.

So the vessel diameter went up about a meter compared to the old SBWR design, and the vessel height is, I think, a meter, a couple of meters higher.

CHAIRMAN WALLIS: It's a very interesting vessel because there's no way to open it.

MR. RAO: Runs forever. No. This is just a cartoon to show you the --

MEMBER POWERS: Maybe the people working in safeguards and security can come up with a way of opening it.

MR. RAO: We wanted to improve the security of the design, right.

Okay. The other couple of things to notice is like a standard boiling water reactor, there is a suppression system. This is what's called the drywell. This is the wetwell. This is the pool of water. It's the same size as the ABWR. It's similar to the ABWR in the sense that you've got the -- this is the connection from the drywell to the wetwell. These are the horizontal discharges, three sets of what we call main vents (phonetic). You'll hear that in the presentations as we go through.

So this is the wetwell airspace out here, okay, and this part out here is where you find the steamline piping, the safety relief valves, and some of them have quenchers going into the suppression pool just like standard boiling water reactors.

There are depressurization valves which come off the steam lines, and some of them have separate nozzles of their own. They do not have quenchers. They open straight into the wetwell.

There isn't much other equipment shown out here. Of the three pools of water, this is what has replaced all of the safety systems, the water make-up systems. It's a combination of the water in the reactor vessel itself and about 1,000 cubic meters of water make-up to provide slow injection into the vessel following a loss of coolant accident.

As you'll see the responses, they'll show you that you don't really need high make-up systems for this.

CHAIRMAN WALLIS: What's that great lattice work of red piping there?

MR. RAO: That's all supports.

CHAIRMAN WALLIS: Oh, supports. That's structure. That's not pipes.

MR. RAO: No, that's structures.

CHAIRMAN WALLIS: It's a jungle gym sort of thing.

MR. RAO: It is jungle gym, but we've also looked at it from maintenance point of view, and we've moved each one of those valves. There isn't much equipment in this building, except there are valves. There are pipes and valves. That is all that is left out there.

MEMBER KRESS: When you evaluate LOCAs for this plant, do you have a drain line in the bottom?

MR. RAO: Yes.

MEMBER KRESS: And you have the control rods. Are those part of the LOCA?

MR. RAO: Yes. We analyze the LOCA except for one drain line also, yes.

MEMBER KRESS: Okay.

MR. RAO: Yes.

CHAIRMAN WALLIS: You can also break the shutdown cooling system in the bottom.

MR. RAO: Pardon?

CHAIRMAN WALLIS: You can break the

shutdown cooling system.

MR. RAO: Yeah. There are actually not one drain lines. There are four drain lines in the bottom, but they are two inch nozzles, only two inch nozzles. They're very small, and we do analyze that.

Yes?

MEMBER POWERS: What has to happen to keep from depressurizing this vessel?

MR. RAO: As you'll see the transient response, you'll see that we don't open the relief valves for falling reactor isolation. So it's a very forgiving machine. Because it has got a bigger vessel, okay, the initial transient response for the first 30 seconds without any system operating, basically you don't open any relief valves and then the isolation condensers come in and take care of the decay heat.

MEMBER POWERS: That's not the question I asked.

MR. RAO: Okay.

MEMBER POWERS: The question I asked is what has to happen to make it impossible to depressurize this vessel.

MR. RAO: What has to happen to make it impossible to depressurize?

MEMBER POWERS: Un-huh. Hypothesize a station blackout as a going in thing. Now, what can keep me from being able to depressurize?

MR. RAO: If you have just a station blackout and no pipe break --

MEMBER POWERS: Naw. Don't assume that.

MR. RAO: I'm just trying to understand what your assumptions are. If you have a pipe break, you are going to depressurize. But if you just have a station blackout, okay, and that has been the dominant sequence for the operating plants, is a station blackout.

In that case, when you just have a station blackout, you don't depressurize the plant, and I'll show you what the response is.

If you have a station blackout combined with a break, then you will depressurize the plant.

MEMBER POWERS: I'm still not getting an answer to my question.

MR. RAO: I must be missing something.

MEMBER POWERS: I'm asking you what keeps your from depressurizing this plant. What has to happen so that you cannot depressurize?

CHAIRMAN WALLIS: Under what conditions?

MR. RAO: Under what conditions? As long

as there's no pipe break -- I'm still -- are you saying what do we have to do to the design to prevent it from depressurizing during a pipe break?

Someone can help me in the back.

CHAIRMAN WALLIS: How can you get into a situation where you're unable to depressurize.

MR. RAO: Where you are not able to depressurize?

MEMBER POWERS: Even with a pipe break.

MR. RAO: Even with a pipe break. Well, if you get failure of both the areas, there are two area systems. We've added the wilsadee (phonetic) and the depressurization system. We've got the standard safety relief valves, and we've added another system called the DPVs, the depressurization valves.

So if both of those fail, then you fail to depressurize.

MEMBER POWERS: Okay. What causes both of those to fail?

MR. RAO: What would cause both of those to fail? Anyone in the back ready to answer that?

CHESTER: All of the valves, they use different --

PARTICIPANT: Could you give us --

CHESTER: I'm Chester (unintelligible).

The ADS valve and the DPV valve, they have diversified single systems that are very hard to have fail all the signals. You're talking about multiple failure of all the signals.

MEMBER POWERS: I'm not really interested -- I mean, I am very interested in what makes it difficult to depressurize or what makes it easy to depressurize. What I very much want to understand is what combination of things make it so that you cannot activate these ADS systems.

Now, obviously if I get no signal to do so, that will do it.

MR. RAO: Yeah, yeah.

MEMBER POWERS: So the question is: what makes it so you can't get a signal to them?

MR. RAO: Well, you've got to, I guess, have a common cause failure. We've got four divisionals in the control and instrumentation. So you have to have a common cause failure in control and instrumentation.

CHAIRMAN WALLIS: But if you had a fire, say, which incapacitated all of the system?

MR. RAO: Well, that's where you have the four division system. So you do the separation to handle -- you handle that. Okay? It is an anergic containment. So there's not going to be a fire inside the containment. The external, you handle that by division and standard separation.

So if there is a common cause failure, you know, an undefined common cause failure of the instrumentation, that will give you a failure to depressurize.

MEMBER POWERS: Is there anything else that will give you a failure to depressurize?

If you have no electrical power whatsoever?

MR. RAO: We rely on batteries for that, but even if you lose the batteries in addition to the station blackout, then you'd lose instrumentation.

MEMBER POWERS: And that will cause a failure of the ADS?

MR. RAO: Yes.

MEMBER POWERS: So a total station blackout is still --

MR. RAO: Total loss of batteries, failure of all the signals.

MEMBER POWERS: That will do it.

MR. RAO: Yeah.

MEMBER POWERS: So there's still a TC sequence here someplace.

MR. RAO: Yeah.

MEMBER POWERS: Okay.

CHAIRMAN WALLIS: I'm a bit worried about failure to complete this presentation on time.

(Laughter.)

CHAIRMAN WALLIS: Okay. The --

DR. BANERJEE: Before you go on, what is different between this and the SBWR? Is there anything in the wetwell/drywell connection design?

MR. RAO: Well, we just got two more steam lines. We got a slightly bigger vessel. This, the top part, the GDCS, these are the pools of water. Those are all the same. This is all the same. The only difference, okay, that's different, and it's hard to show that kind of detail in this cartoon, is in the SBWR. These pools were open at the top out here. The roof of the drywell is out here. Okay? The top part was open to the drywell.

In the ESBWR this wall goes up to the roof of the drywell, and this pool of water is now part of the wetwell.

So all that we did was we extended this wall up to the roof. It was about a foot opening, I think, in the SBWR. So we've extended it up to the top and put a connection between this airspace and this, the wetwell airspace.

MR. SCHROCK: Is that permanently open or --

MR. RAO: Yeah, all those are permanently open. No valves.

So otherwise it looks just like the ESBWR.

MR. SCHROCK: Why did you do that?

MR. RAO: You'll see that basically what it does is remember the containment pressure is dependent on the wetwell volume, airspace volume. Okay? So this was, again, taking advantage of the passive system.

When this water drains out, okay, then it opens up more airspace. So it loads the containment pressure. Okay? So there's an advantage.

CHAIRMAN WALLIS: Well, there's a conservation of airspace. If you lose it in one place you gain it in another.

MR. RAO: Right. No, but you want more airspace in the wetwell. That keeps your containment pressure lower. So we actually did lower the containment design pressure compared to the SBWR. That doesn't show on a chart like this. We came down ten psi. That's, again, an economic benefit, but we kept essentially the same margins by making that change.

MEMBER POWERS: Can you give me some idea of the what the magnitude of the economic benefit is to get ten psi reduction in your design pressure?

MR. RAO: No, I don't have a number for that, and we never did calculate one. As a matter of fact, again, one of the reasons for doing that was it brought us down to the same level as the ABWR. Okay? So there was a lot of experience with that, you know, a lot of the testing on serial accident failures.

So there was that soft benefit of making the same as ABWR.

CHAIRMAN WALLIS: I'm not sure you gained because you actually put water in the drywell. Your total airspace stays the same inside containment if you include the whole works.

MR. RAO: There are two issues here. One is the volume of the building, and the other is the design pressure of the building. Okay? So Dana's question is related to the design pressure. It does end up in giving you less rebar requirements. We've actually --

MEMBER POWERS: That's the cheapest deal in America is rebar.

MR. RAO: No, rebar itself is cheap, but

putting it together, constructing it. We have actually gone down to even lower than the ABWR and our structural designers told us it wasn't any additional benefit. So we came back to --

MEMBER POWERS: I'll bet you run out of benefit really quickly on rebar and concrete.

MEMBER RANSOM: Are vacuum vapor valves still included in this design?

MR. RAO: Yes, there are three vacuum breakers between the -- they're on the floor out here between the drywell and the diaphragm floor.

MEMBER POWERS: Remind me again what your containment volume is.

MR. RAO: Sorry, I don't. Does anyone have the number off the top of their head?

PARTICIPANT: The drywell is about 6,000 kilometers. The wetwell is about 4,500.

MR. RAO: That's the airspace.

PARTICIPANT: The airspace.

CHAIRMAN WALLIS: You should really count the whole thing. What's the whole containment?

MR. RAO: The whole containment volume, you don't have the answer?

PARTICIPANT: I don't have it. I don't know.

CHAIRMAN WALLIS: Well, you have about five minutes more now in presentation time.

MR. RAO: Okay.

CHAIRMAN WALLIS: So you're about a quarter of the way through. Maybe we should plan on you taking up all the time until the break. Is that more realistic?

MR. RAO: No. When we sort of planned it, we sort of anticipated that I'd run over a little, but not --

CHAIRMAN WALLIS: A little bit.

MR. RAO: -- not all the way to lunchtime. You want to hear the other things.

CHAIRMAN WALLIS: Lunchtime? No, no, no, no, no.

MR. RAO: You want to hear from some of my colleagues. You get all of your answers from Shiralkar and Gamble and Cheung there.

Okay. This shows all of the safety systems put together, including all of the valves, and the thing that's -- let me go through all of this. This is the reactor vessel. You can see the core. The core is lower down in the vessel in this plant than in the standard BWR. There's a shorter core. So you need less space at the bottom, lower plenum for the control rod --

CHAIRMAN WALLIS: That's really to scale?

MR. RAO: Pardon?

CHAIRMAN WALLIS: Is that really to scale, that tiny core?

MR. RAO: No. This is just to show how the --

CHAIRMAN WALLIS: You should draw these things to scale so it doesn't give some illusion.

MR. RAO: This was more to show you how the lines connect up. Okay. We will try to fix that in the next one. This is the isolation condenser out here. This operates like some of the isolation condensers on operating plants.

When you get to reactor isolation, these valves are normally open. The valve is out here. The condensate drain valves open, a signal to open. Steam condensers in there and condensate is returned to the vessel. So you've got a closed loop following reactor isolation. You don't open any relief valves. You don't lose any water to the containment. You don't heat the containment. You don't need any of the reactor coolant isolation condenser type of systems to operate or you don't need any cooling system to operate.

The energy is removed to the spool of water which is sitting outside the containment, and the energy is release to the atmosphere.

DR. BANERJEE: It's still downflow condensation.

MR. RAO: Yes.

DR. BANERJEE: And somebody will tell us about the non-condensables.

MR. RAO: This is reactor isolation. There should be no non-condensables.

CHAIRMAN WALLIS: There's a vent line for that.

DR. BANERJEE: Oh, okay.

MR. RAO: Okay. But if you operate it for 72 hours, okay, this is designed to operate for 72 hours. Okay? It can. Then you'll get some radialysis (phonetic) which will produce hydrogen, and then you'll get non-condensables.

In that case, there is a vent line out here. It will open and release the non-condensables.

CHAIRMAN WALLIS: And all of this has been tested at full scale?

MR. RAO: Yes, yes.

CHAIRMAN WALLIS: In Japan or somewhere?

MR. RAO: In Italy.

CHAIRMAN WALLIS: Italy. That's the Italy one.

MR. RAO: Okay. So this is the isolation condenser. This is considering they let the plant sit there for 72 hours, which it probably likely wouldn't. The gravity driven cooling system pools are shown out here. This is that pipe that I mentioned. This is the change from the SBWR where we went all the way to -- came to this wall up to the top, and we added this connection between that air space and the wetwell airspace.

What it does is it makes this airspace available long term when that pool drains. So it lowers the long-term containment pressure.

MEMBER KRESS: How big is that pipe?

MR. RAO: How big is that pipe?

CHESTER: Half a meter.

MEMBER KRESS: It's a big pipe.

MR. RAO: Yes.

MEMBER SIEBER: You have to use the microphone.

MR. RAO: You have to stand near the mic.

CHESTER: It's a big pipe.

MEMBER KRESS: Yeah, okay.

CHESTER: There are three pipes for each

of the pools.

MEMBER KRESS: Okay. Because the effectiveness of that as an airspace depends on the size.

MR. RAO: Yeah.

CHAIRMAN WALLIS: You mean the pressure in that wetwell is somehow different from the overall pressure in the building?

Because if you look at the entire containment, the total amount of air in there is constant. You can tree it off between the drywell and the wetwell. You haven't really gained airspace.

MR. RAO: You have. What controls the containment pressure, okay, is you take all the non-condensables from the drywell and shove them into the wetwell.

CHAIRMAN WALLIS: And you pressurize the wetwell referentially to the --

MR. RAO: No, that's how the suppression system works, is this is where your source of energy is. This is where the brakes and the steams will come out. So it will push all of the non-condensables into this airspace.

So the bigger this airspace and the smaller this airspace, the lower your containment pressure. Okay? So you want to minimize that airspace and maximize this airspace.

And so by shifting it between the two you will maximize the wetwell --

CHAIRMAN WALLIS: You mean your wetwell gets higher pressure than the drywell?

MR. RAO: Yeah.

CHAIRMAN WALLIS: Then you should vent it back into the drywell.

MR. RAO: No, because you've got to remember the reason it gets higher is because everything is being pushed through two flow paths.

CHAIRMAN WALLIS: How does it get pushed if the pressure is higher in the wetwell than in the drywell?

MR. RAO: You guys want to go through that? Okay.

CHAIRMAN WALLIS: Well, I don't know. Maybe we'll wait and hear about that.

MR. RAO: We'll wait while we get the presentations. Okay?

CHAIRMAN WALLIS: Okay.

MR. RAO: The containment pressure is determined by the wetwell pressure. Okay.

CHAIRMAN WALLIS: Well, it can't be.

We'll get back to that because the whole thing is one unit, isn't it? And the containment has to contain both the drywell and the wetwell.

MR. RAO: Yes.

CHAIRMAN WALLIS: So let's get back to that when the time comes.

MR. RAO: You'll hear detailed presentations on that, okay, shortly.

This is the GDCS pool. This is the suppression pool. These are the safety relief valves that have quenchers blowing down into the suppression pool.

This is the depressurization valve, the alternate depressurization system which opens out into the drywell.

CHAIRMAN WALLIS: That's called the Dana Power's valve. That's DPV because that's the one he's concerned about.

MR. RAO: We added the diversity because we knew Dana was going to ask that question to make it more reliable.

The ADS system in the BWR generally is deemed to be fairly reliable, but we've gone to a diverse system also. It's a screw actuated (phonetic) valve. So it has different motor flows to open it.

What's shown out here is the passive decay heat removal system, which is called the passive containment cooling system. No valves for it to operate. Okay?

CHAIRMAN WALLIS: I presume an explosive valve requires very little electrical energy to set it off, whereas actually operating a large motor operated valve would require a lot more power.

MR. RAO: A lot more energy, yes.

So we do have batteries to as --

CHAIRMAN WALLIS: So you could take your flashlight and set off the explosive valve.

MR. RAO: Yes. That's why we believe it's a very reliable system.

The passive containment cooling system --

MEMBER POWERS: What is the reliability of screw actuated valves?

MR. RAO: Pardon?

MEMBER POWERS: What is the historical reliability of screw actuative valves?

MR. RAO: Don't have the number on that, but we can get back.

MEMBER POWERS: I think we found it surprisingly unreliable.

MR. RAO: We'll give you a number.

Do you have the number, Bob? No. Okay.

The passive containment cooling condenser, basically steam goes up through here, and just like the isolation condenser, steam gets condensed there, and condensate is returned back to the vessel.

This is one other change relative to the SBWR. We've added this system. In the SBWR this condensate would return to the gravity driven cooling system pool, but now since the GDCS pool is part of the wetwell, we had to bring the drain back into the drywell.

So initially in some of our earlier designs we actually didn't even have this drain tank and it would just flow back into the bottom of the drywell.

We added this drain tank because we felt that it would be better to have it drain back into the vessel. If this valve does not open, the functionality of the ECCS is not impacted. Functionality of the system is not impacted. Water does drain back into the vessel -- I mean into the lower drywell, and you still have a closed loop.

So the steam is condensed out there. The energy is removed to the PCCS pool, and steam if vented out of the containment. That is the ultimate heat sink out there.

DR. BANERJEE: So if that valve doesn't open, then you get water going in. Where does it go?

MR. RAO: It goes into the lower drywell. Okay? Then you have a closed loop. The closed loop is through here. These are what are called spillover holes here. It flows into the suppression pool. There's a line connecting the suppression pool back to the vessel, the screw valve. So you have a closed loop.

So we have looked at all of the different possibilities, not enough time to go into each one of the combinations out here, but you have a closed loop and the water can go back through the vessel.

CHAIRMAN WALLIS: So most of the water in this containment building is available to cool the core.

MR. RAO: Yes, to cool the core. You know, we've got an expression pool also connected to the vessel. We've got GDCS pools connected to the vessel.

One thing that's different than standard BWRs is the suppression pool is raised to the core. Most suppression pools are on the base mat out here. This one is higher than the core. So you can get the flow from the suppression pool into the vessel.

CHAIRMAN WALLIS: Even when the core is drawn properly, it's still higher?

MR. RAO: Yes, still lands it on top.

DR. BANERJEE: And the PCC vent line is at the bottom there, right?

MR. RAO: Yes, yes.

DR. BANERJEE: Is that assuming that non-condensables get driven into that?

MR. RAO: No. Now, non-condensables are important in the operation of the PCC because you've got non-condensables in the drywell. Okay? So the condensation, the steam flow is similar to the isolation condenser, but it's a condensation driven system.

Okay, and that brings in non-condensables with it. The major innovation in this design is removing the non-condensables, and the non-condensables are driven out from there by the pressure difference between the drywell and the wetwell. The drywell is at a higher pressure than the wetwell. I think I said it the other way around.

Okay. The drywell is at a higher pressure than the wetwell, and that drives the non-condensables out through that non-condensable vent line.

There will be several more presentations that will cover all of that. That's been tested. That's how it works. I'm just giving you an overview.

And what determines the ultimate containment pressure is the modern non-condensables. You put them in the wetwell airspace. That is the major component of the containment design pressure following the LOCA. All of that air gets pushed over, and there is some vapor pressure because there's a slight heating up of the suppression pool. The suppression pool in this plant only heats up because of blow-down energy. Okay?

In a traditional boiling water reactor, what you do is the first part of the transient is the same. All the air following a pipe break gets pushed over into the wetwell airspace. That gives you a certain pressure.

And then what happens is the energy from the drywell gets transferred to the suppression pool. The suppression pool heats up. It gives you an increase in the vapor pressure which causes the condensed pressure to heat up.

The active RHR system removes the energy from the suppression pool. It is only effective at a certain delta T. So you've got to heat up the pool to remove this energy. In this plant the difference is we remove the energy before it gets to the suppression pool through these heat exchangers.

Just to give you some ball park numbers, in a operating plant the suppression pool has to get up to 212, 220 before the RHR system is effective in removing the decay from the containment.

Following an initial blow-down, assuming that the suppression pool starts at 110 degrees, the initial blow-down gives you about a 30 or 40 degree increase in the suppression pool temperature. You get a similar increase, slightly less increase in this line, because some of the energy actually goes out through the heat exchanger.

CHAIRMAN WALLIS: Does the pressure pool get to, say, 220 Fahrenheit?

MR. RAO: No, not in this plant, not in this plant. In operating plants, it will get up -- for the RHR system to be effective in operating plants, you'll have to get the suppression pool up in temperature. That's how the system works. For the delta T, you need a higher delta T to remove that energy.

Okay. In this plant it's primarily the blow-down energy that heats up the suppression pool.

So that's a 30 to 40 degree increase in temperature from the initial starting temperature. If you go with the tech spec, I believe it's 120. One, twenty?

CHESTER: One, twenty.

MR. RAO: One, twenty. So you get a 30 to 40 degree increase in temperature by the initial blow-down, and then for a short time period these heat exchangers cannot remove all of the energy, and you get a slight increase in temperature beyond the initial blow-down. Okay? And that gives you a vapor pressure that gets up to 180, 190 at this plant.

In the operating plant, you get up to 220 degrees, beyond that.

Okay. So what determines the containment pressure in this plant is primarily the drywell volume. Take all of that air and shove it into that space. Do that on the back of an envelope, and about a five to eight psi vapor pressure from the heating up of the suppression pool.

So it's a fairly simple calculation as long as these heat exchangers are properly sized, and as you will see in the presentations, these are properly sized.

This is the 13 pump story. For those of you who don't like passive systems, you can see that what we have for core cooling is we've done several things in the design to improve the plant response. We've increased the inventory in the vessel. You'll see a chart that shows that we've got two and a half times as much water.

We've increased the amount of subcooled water. Chester will go into a lot of details on how the plant behaves and where the water is.

We've eliminated large pipes from below the core. We've minimized the other pipe sizes. Like I mentioned, the only pipes that are connected at the core, near the core elevation are two inch nozzles. So we've kept them down to very small sizes.

Well, we provide inventory makeup. We don't need a fast makeup system. Okay? The makeup rate is very low, as you'll see the plots out here. You don't reach the minimum water level until at least 600 seconds into the transience. That's when you depressurize the vessel, and all that you have to do is make up the water that's lost by boil-off.

So you don't need any accumulator driven system. You don't need any high pressure injection systems because the plant actually reacts fairly slowly.

Now, because you don't have any high

pressure systems, any accumulators or other core makeup tanks or any of the other issues that you might see on other plants or high pressure coolant injection systems, like on BWRs, you see fewer system interactions. The only high pressure system that exists on this plant is the isolation condenser, and we don't take credit for that in the loss of coolant accident analysis.

CHAIRMAN WALLIS: If this is such a wonderful system, how come it has taken 15 years before anyone is seriously looking at it?

MR. RAO: Well, when you look at the market, there hasn't been a plant --

CHAIRMAN WALLIS: The market has been lousy.

MR. RAO: And the other thing that's different out here is we are now using an integrated analysis. You know, when I first joined General Electric, I worked out here, and I defended using all the different codes, you know. We had to use LAMB/SCAT, SAFE, SAFER, CHASTE, and all of those things for doing all of the calculations.

Now we have got an integrated core. What you asked us to do -- all of you weren't on the committee then -- was to develop an integrated core.

We've got one now. It's there. It doesn't do everything. It doesn't do windows, but it does do an excellent job of doing the calculation.

In the interest of time I will skip through a few of the charts.

On the decay heat removal system, basically what we do is remove decay heat from the vessel. What's new in this plant is we've now got a full pressure, novel shutdown cooling system. We rely on isolation condensers. In some of these cases they're old. We've gone back to features that were in the older BWRs.

We can remove SLV through relief valve opening. I mean you can open the relief valve. You do have a non-safety grade suppression pool cooling system. So you can do that also. So for those who like some of the old features, they're still there.

And of course, if needed, if you get a pipe break, we basically remove heat from the containment through the ECCS heat exchangers, which are new. I'll discuss those in some time.

Of course, we do have a suppression pool cooling system in this plant also, but it's a non-safety system. So the pumps and heat exchangers that we had in the old plants are still there.

Decay heat removal, how it works. I discussed this briefly in some of the earlier charts. You get the blow down energy, which flows to the suppression pool, traditional pressure suppression system.

Longer term, the decay heat flows through the heat exchanger similar to an isolation condenser, and heat is transferred outside the containment. You've got tube heat exchangers. The non-condensables are removed by the pressure difference between the drywell and the wetwell. Like I mentioned earlier and corrected myself, the drywell is at a higher pressure than the wetwell, but the drywell pressure --

CHAIRMAN WALLIS: It's always at a higher pressure than the wetwell?

MR. RAO: Except for a short time period, and I'll show you the transience when that happens. When you condense the steam in the drywell, you know, after the initial blow-down and you condense the steam, when the water from the gravity driven cooling system flows in, it condenses the steam. So the pressure in the drywell will come down for a little while, and then you pull the non-condensables back.

CHAIRMAN WALLIS: That's right. You suck it, suck up out of the suppression pool.

MR. RAO: I was wrong when I made my earlier statements. I guess maybe I'm getting old and forgetting some of these things as we go along.

No, but that's how it works. You'll see details on that.

MEMBER POWERS: Will we discuss the capabilities of the plant during shutdown refueling?

MR. RAO: We were not planning to discuss that, but I can address that right now. Basically, the same system is still available for that, except for the water makeup system. The gravity driven cooling system is still available. Okay?

You've got the vessel that's full of water. The one thing that's --

MEMBER POWERS: I mean that's the question that came to my mind. You've got a core very low and a very tall vessel, and I was wondering how low do you have to drop that water for your refueling process and service all of these systems that come in above the core.

MR. RAO: The vessel is actually full of water at that time, during the refueling. So just to give you a feel for some of the numbers, let me go back to --

MEMBER POWERS: I mean, what comes to mind is -- this is a good one.

MR. RAO: Okay. Let me give you a feel for some of the numbers. The vessel volume is about 500 cubic meters. Okay? This lower drywell is 700 cubic meters. Okay?

One of the neat things about this design is this pool of water is 1,000 cubic meters. Okay? And the vessel is full of water. Okay. During the --

MEMBER POWERS: But is it full of water if I am servicing my squib valves?

MR. RAO: Yeah, there are check valves, and there are block valves all along the line.

MEMBER POWERS: The system. So you don't have to take the water level down before --

MR. RAO: No, you don't have to take the water level down during an outage.

MEMBER POWERS: And you don't have anything like an operational mode five here then where you have low inventories and safety systems taken out.

MR. RAO: No.

MEMBER POWERS: Okay.

MR. RAO: Okay, but the thing that's different is that this lower drywell volume is about 700 cubic meters. It's a lot smaller than that for the operating plants, okay, and so it doesn't take that much water to fill that up. That solves the simplistic way of looking at it.

CHAIRMAN WALLIS: When you refuel, do you take out all of the baffle that are in the chimney as well?

MR. RAO: Pardon?

CHAIRMAN WALLIS: When you refuel, you have to take out all of the baffle you've got in the chimney?

MR. RAO: Not in the chimney.

CHAIRMAN WALLIS: You leave them in?

MR. RAO: We leave them in.

MEMBER FORD: Atam, could you go back to that previous graph? Since we're going to have a free flow question period, has there been a materials design review undertaken?

MR. RAO: No. We are using the same conditions as that for an operating plant. So we're assuming the best --

MEMBER FORD: I ask this question --

MEMBER POWERS: If they've been so successful, Peter, why would they possibly want to change?

MEMBER FORD: Well, I asked the question a while ago to you, and the answer was that materials of construction would be essentially those for an ABWR.

MR. RAO: Right, exactly.

MEMBER FORD: As I look at this design, the difference, of course, is a huge chimney. Everything above the core, and I'm assuming you'd be using hydrogen motor chemistry; everything above the core will be not a very efficient water chemistry. Therefore, everything above the core, regardless of whether it's L grade or not, stainless steels, could crack.

Has that been taken into account? Obviously not.

And if it did crack, what would the impact be?

MR. RAO: Okay. It's been taken into account in the sense of, one, we made sure that all the components inside the vessel are removable easily. They aren't welded anymore. Okay? So we made them replaceable.

And so in that sense we have taken that into account. And we've made sure there's enough hatches up in the top. We have a plan to remove the largest components through the refueling floor and out of the containment.

MEMBER FORD: I'm assuming a materials design review will be undertaken.

MR. RAO: Yes, definitely.

MEMBER FORD: In time so as not to be a rate limiting step if you have to come up with a new material.

MR. RAO: Yes, it will be. That will be all done as part of the SAR submittal. Right now remember we are focusing on thermal hydraulic calculations rather than on the actual design.

MEMBER FORD: The other question along those lines, I'm assuming it will be nobel metal chemical addition you will be also using in addition to hydrogen water chemistry. Will calculations be done as to how efficient that application will be and whether you can protect all of the wet components?

MR. RAO: We expect to do all of that, you know, in time for the SAR submittal.

What we have done in this program -- let me step back a little bit -- is by experience with the SBWR was we did technology review, testing, safety analysis report, all in one big package, and everything was going on in parallel.

What we've tried to do in this program is let's do it step-wise. Let's get a few things off the table and see if we can get them off the table.

Okay. So the pre-application review is not focusing on the design materials and any of those issues.

MEMBER FORD: Even though they may impact on safety?

MR. RAO: Yes. There are a lot of design issues that impact the safety and will affect the PRA and all of the rest. What we are trying to do is get closure on the thermal hydraulic spot of the analysis on the completed codes because that in the past has been the biggest uncertainty or whatever for getting these moving forward.

If we can't even get this closed out, then you know. You've got to remember that we have not been using any government money for the last ten years to develop. This has been a totally industry effort, and if we can't see the light of day in this tunnel even on this one, then the other ones will be even harder to get to.

CHAIRMAN WALLIS: Well, I think it's good to let you take the time until the break.

MR. RAO: Okay.

CHAIRMAN WALLIS: But I think that's really definitely the ultimate time that you have.

You don't have any longer than that.

I think it's good because there are so many questions that it's useful to the Subcommittee, but that is the deadline.

MR. RAO: Okay.

CHAIRMAN WALLIS: So let's move along.

MR. RAO: We will get into how the PCSS works in some of the later presentation, but it's important to understand how they work. Some of the charts have not come out too good on the screen, and I don't know why.

It's a standard plant schematic. What you can't see out here -- the pictures are better in your handouts?

PARTICIPANTS: Yes.

MR. RAO: The thing to notice out here is the major water systems which have the simplification you wanted to hear about the economics is the reactor water clean-up system at the bottom. I think this is the fuel pool cooling system out here shown on the left, and the control rod drive hydraulic system.

Those are the only systems left in this design, and that's where the simplification comes from. That's where the economics comes from, is basically in reducing the amount of materials and quantities that exist out there. All of the safety systems are basically inside the containment or sitting on top of the containment as shown out here for the IC and PCC pools.

This shows the evolution of the BWR containments. It's important to understand this as background as we go forward. All except for, I believe, one or two plants was at Big Rock Point and Humbolt Bay, were I think not suppression systems, but we've had suppression systems in Mark Is, Mark IIs, Mark IIIs.

Basically the major suppression pool is out here. You've got the drywells and the wetwell airspace. The Mark II, where the drywell was sitting on top of the wetwell, and the Mark IIIs where the drywell was surrounded by the wetwell airspace out here.

In all cases the suppression pool was low in the building. That was, again, reasons for because of MPSH considerations for the safety system's pumps, because you needed to take the water from there and put it back in the vessel.

The ABWR basically is similar. You've got the precious suppression sitting out on the base mat out here -- the suppression pool, I mean, sitting on the base mat out here. You've got a T shaped driver because you don't have the recirculation pumps that you have the extent of loops that you have on some of the earlier designs, and the drywell airspace is primarily controlled by the space required on the top by the maintenance of the safety relief valves.

So you've got right circular cylinders, concrete containment, covered suppression pool that's noted, and you've got horizontal vents that we developed on the Mark III.

The ESBWR took features from both the ABWR and the Mark III. We've got a separate fuel building. You can see in the earlier designs and the ABWR this hash mark out here is not a bar code. That is spent fuel storage. Okay?

And like the Mark III, we've put it in a separate fuel building. We've got an inclined fuel transfer system, but, again, we wanted to make improvements.

What we have done is, of course, I've mentioned the raised suppression pool off the base mat which provides a means to provide water makeup from multiple source.

The inclined fuel transfer, that's what IFTS stands for, the top part of it is not part of containment like it was in the Mark IIIs. So you can actually move fuel during novel operation. You don't have to open the containment to make sure that that system is functioning and all the rest of it. So that is an improvement over the Mark III.

CHAIRMAN WALLIS: Now, this shows an ASBWR vessel has actually a shorter L over D than the Mark II. Is that -- it has a longer L over D, doesn't it?

MR. RAO: I know you -- this is more to show some of the features. Okay? this is not necessarily drawn to scale out here, please, and we will try to fix it in the next round.

MR. SCHROCK: I would wonder why you didn't include SBWR in this comparison.

MR. RAO: It got too complex, and it wasn't adding anything. The key features that I'm trying to show out here, okay, the differences between SBWR and ESBWR are not, as far as containment is concerned, are not that significant. It was just a matter of -- I always run over time. I'm trying to shorten this out here. That was it. No other reason, nothing more complex than that.

CHAIRMAN WALLIS: Okay. We're going to move on? Are we going to move on to the next one now?

MEMBER SIEBER: Well, the ESBWR is not

innurded (phonetic), right?

MR. RAO: It is innurded just like ABWR. All of these things, okay, were adopted by the ESBWR.

MEMBER SIEBER: Okay.

MR. RAO: Innurded containment, horizontal vents, same as ABWR, covered suppression pool.

MEMBER SIEBER: So you actually could not move fuel during operation.

MR. RAO: No, no. You can't get into the containment in the operation. You can move fuel up here. You can. This is not innurded. This is not part of containment.

MEMBER SIEBER: Okay.

MR. RAO: So you can move the fuel up and down, and you see we have a buffer storage up on top. You can actually move it and keep it there ready to --

MEMBER SIEBER: So the upper portion in the fuel building is not subject to containment pressure driven actions.

MR. RAO: Right. Both this part --

MEMBER SIEBER: Yes.

MR. RAO: -- and this part are not subject to containment pressure.

MEMBER SIEBER: And so they aren't

designed for containment pressure, right?

MR. RAO: They are not designed for containment pressure.

MEMBER SIEBER: Thank you.

MR. SCHROCK: Do you use the concept of a secondary containment? Is that what that is there?

MR. RAO: And that is also what's an undefined external event shield. As the requirements are evolving, we don't want to be the first on that, but we have the space for it. This can take care of anything that might come falling from the skies. It's undefined. We have not designed it structurally yet. We can make it as thin or as thick as we need it.

This shows an actual drawing cut-away of the section. You can see that there actually is not much equipment in this building. There's just some equipment down here. The reactor vessel and the piping, and that's what gives it the simplicity.

This is the inclined fuel transfer. You can see the spent fuel pool. This is grade elevation here. Okay. It is essentially below grade there.

This is the fuel pool cooling system. So all of the water systems are done out here.

MEMBER SIEBER: Now, if I look at the core relative to the suppression pool, only about half of the water in the suppression pool is available for core flooding; is that correct?

MR. RAO: Actually, you know, a two dimensional picture is very misleading.

MEMBER SIEBER: Yeah. That's the best you can do.

MR. RAO: In a two dimensional picture you don't really get the true feel of it. This water level only drops by half a meter or something when you flooded everything in the bottom. Okay?

That's about 3,000 cubic meters, and the total volume in the bottom was 700 or some

MEMBER SIEBER: But that reactor vessel to some is very large. From the tip of the control rod drives to the top is over 100 feet.

MR. RAO: Yeah, but you don't have to flood that to get the --

MEMBER SIEBER: That's right.

MR. RAO: You only have to flood the lower part out here. In fact, that is one of the advantages. You've got the core lower than the vessel. You don't have to flood it too much.

MEMBER SIEBER: Yeah.

MR. RAO: This is the refueling floor. This is what I was mentioning. This is the pool up on the top. Inclined fuel transfer comes up there. You can store 70 percent of a core up there. Okay? So you can move stuff in and out during novel operations.

Again, we were trying to make it easier for the utilities.

This one is an important chart. I want you to know because for a couple of reasons. We have greater water inventory, which gives us improved LOCA performance, and we have a larger steam volume in the vessel, the bigger vessel. That's where you start from. You make your vessel bigger. You'll get improved performance of the plan from a safety perspective.

So since the focus here is on safety, what you can see is we've got rid of the large pipes below the core, ESBWRs on the left side. We got a shorter core. So the core is actually sitting lower in the vessel. This is the ABWR out here. It's sitting higher because you've got to have the cold space for the control rod drive. So the core is sitting a little higher.

The top of reactor fuel above the RPV bottom, you can see is much lower. Okay? So you don't have to fill up the whole vessel, and this is the bottom line. The water volume outside the shroud.

Okay?

Chester has color pictures in his presentations. That is what determines the LOCA performance. Okay? You end up with a lot more water that's available for flooding the core, and you don't have to provide it from outside. It's there inside the vessel, and you'll see how the plant behaves.

And the other thing is because of the chimney, you've got much larger steam volume. You'll see the pressure rate is about half that of an operating plant off an ABWR, and that's because you've got about twice the steam volume. I mean, you don't need a computer code for that. It's just the simple numbers and the size of the vessel.

This shows the plant response, and this is what I was trying to say earlier. If you look at most of the operating plants in the U.S., all of the operating plants in the U.S., jet pump plants, for a couple of them, the water level drops very rapidly below the core, and you have fast pump ejection. That's what makes up the water level.

This is the water level following a typical pipe break. ABWR, the water doesn't drop below the top of the fuel because we've eliminated the large pipes.

CHAIRMAN WALLIS: This "typical" means worst?

MR. RAO: The actual TRACG plots, this is a simplified plot.

CHAIRMAN WALLIS: They're all like this for all pipe breaks?

MR. RAO: For the ESBWR, yes. For these plants, they are not. For ESBWR, --

CHAIRMAN WALLIS: So for all pipe breaks, the core level is way above the top of the core with ESBWR.

MR. RAO: On the ESBWR, you can see the numbers. It's three meters --

CHAIRMAN WALLIS: That's the message you want.

MR. RAO: It's nine feet above the top of there. No, there's a couple of other messages I want to give to you out here.

One is that the minimum water level isn't reached. You don't even start injection -- "injection" is the wrong word -- water doesn't start flowing by gravity until about five or 600 seconds into the transience. Things do not have to act very fast. This response here, this first part is just what's in the vessel. Nothing is going to come outside. This is what's flowing out, okay, and what's available inside the vessel.

CHAIRMAN WALLIS: So this is also good from the point of view of operator action?

MR. RAO: Yeah.

CHAIRMAN WALLIS: Operators don't have to do anything?

MR. RAO: No. No operator action is required. It's all in the vessel. Everything is there. Okay? So nothing happens from outside until that time period, 600 seconds. You don't need fast makeup. You don't need any.

And then when you see the actual plot, you can delay the injection several hundred seconds or they'll give you some numbers they've drawn.

CHAIRMAN WALLIS: I'm tempted to say that the reason this wasn't built 30 years ago was that someone had the crazy idea of putting these things in a submarine so that they couldn't be too tall.

MR. RAO: Submarines are 50 years ago, 60 years ago.

CHAIRMAN WALLIS: Well, an awful long time ago, probably before you were born.

MEMBER KRESS: What causes the recovery in level at 100 seconds?

MR. RAO: Oh, okay. This is what happens is you start opening the break transition valves, flashing going on inside the vessel.

MEMBER KRESS: Oh, that's the --

MR. RAO: That's the depressurization start.

MEMBER KRESS: Oh, okay. That's just the --

MR. RAO: Just the two phase level.

MEMBER KRESS: Two phase level.

MR. RAO: You'll see a lot more different plots. This is just to give you somewhat of an overview here.

MEMBER RANSOM: What do you mean by the shroud, change in terminology there? Is that the annulus?

MR. RAO: Inside this thing this is the shroud. Okay? This --

MEMBER RANSOM: So is that a collapsed water level?

MR. RAO: This one?

MEMBER RANSOM: Well, yes.

MR. RAO: This is a two-phased level (phonetic).

CHAIRMAN WALLIS: So it's steam above.

MEMBER RANSOM: Three phase or collapsed --

MR. RAO: Two phase. You'll see a lot more details on collapsed and two phase and all in the later presentation. This is the two phase level. You'll see a lot more detail as we go along, and you can look at it from collapsed levels. You can look at it from two phased levels. You can look at downcomer levels, shroud levels.

The key thing is the water level and the shroud. That's what keeps the floor covered.

Okay. This shows the containment pressure, the function of time for the --

CHAIRMAN WALLIS: Does it ever come down?

MR. RAO: Pardon?

CHAIRMAN WALLIS: Does it ever come down? It seems to be creeping up.

MR. RAO: A passive system will not get down to ambient conditions.

CHAIRMAN WALLIS: So it stays up at .8?

MR. RAO: Yeah, it stays up there. That's true. Because remember what keeps the pressure up is the air goes from the drywell to the wetwell. It's not a heating issue. It's not a safety issue. It's a question of just the air being in the -- from the drywell being pushed into the wetwell. That is really what --

CHAIRMAN WALLIS: Then what's in the drywell? Just steam?

MR. RAO: Steam.

CHAIRMAN WALLIS: Well, eventually that's going to disappear.

MR. RAO: Pardon?

CHAIRMAN WALLIS: Eventually that will presumably go.

MR. RAO: No.

CHAIRMAN WALLIS: No?

MR. RAO: Decay heat will keep it there.

CHAIRMAN WALLIS: Oh, okay.

MEMBER POWERS: It depends on the definition of "eventually." Eventually decay heat goes away and then you're all dead.

MR. RAO: Eventually you'll have to turn on your pumps. Okay? There's no -- okay. The passive system will never get you to ambient conditions.

Okay. There's an extensive test program. I've just given you an overview. We've done component costs. We've done integral tests, different scales, different countries, a system interaction test. We've even done tests with hydrogen releases. Basically the testing is used to qualify the computer code.

And there's been extensive review and participation by the NRC staff in the tests matrix both from the SBWR program, all on the SBWR program, and the running of the actual test.

A key point in our presentation is that all of the testing that was done for SBWR we believe is sufficient for the qualification of the TRACG computer code. However, we did additional confirmatory testing for the ESBWR in one of the test facilities, and we'll present results from that also.

MEMBER KRESS: I presume you base that on a PIRT and a scaling and pi groups that are --

MR. RAO: Right.

MEMBER KRESS: -- basically the same?

MR. RAO: Right, exactly.

CHAIRMAN WALLIS: Actually I think you try to do everything at full scale in the sense that it's full height.

MR. RAO: Well, we --

CHAIRMAN WALLIS: The only thing that is compromised is the diameter of things.

MR. RAO: Well, the component tests were

full scale for the SBWR size.

CHAIRMAN WALLIS: As much as possible, right.

MR. RAO: We did -- as far as DPVs and vacuum breakers and all, those are full scale components. The only thing that's not full scale for the SBWR and ESBWR is the PCCS heat exchangers.

CHAIRMAN WALLIS: Just the system, yeah.

MR. RAO: PCCS heat exchangers. Okay? We've made them 35 percent bigger. We just increased the number of tubes. Okay? So that is another difference compared to the --

DR. BANERJEE: And the chimney is different, right?

MR. RAO: The chimney is the same as the SBWR ones.

DR. BANERJEE: They're the same size?

MR. RAO: Yeah, the one meter by one meter diameter.

DR. BANERJEE: Right, and the length was?

MR. RAO: Length may have gone up by about a meter or so.

CHESTER: It's just a little bit longer.

MR. RAO: Or half a meter. I don't know what the exact number is, but it's up a little bit.

Okay. So we made extensive new submittals. You can see out here we've -- like 7,000 additional pages of submittals compared to the SBWR. We are relying a lot on the SBWR. So that was a complete and extensive program.

This shows the overall technology program elements. You'll hear on this the testing and analysis program next. It's called TAPD. You'll hear that acronym many times. This gives you what we did on the PIRTs, what was required for qualification.

That defines the overall plan. Okay?

With regard to the TRAC model description, we got what we called the TRAC base qualification. That was a report that was submitted and approved by the NRC earlier for operating plants' AOOs, as shown out here. So these three on the right had been submitted earlier to the staff.

Some of the ones out here with the dashed colors in the blue are some that were submitted for the SBWR. The ones that don't have any color in them are new or unique submittals in support of this ESBWR technology closure.

We've got a scaling report. You'll hear about that. You'll hear about the SBWR testing summary. You'll hear about the ESBWR specific tests that were run. You'll hear more on the TRACG qualification, how we do the model bias and uncertainty, and that gives us the validated core, and that's what we're looking for in this part of the program, an SER on that.

Basically the SER -- sorry -- is on the application methodology. I'm sorry. it's not on the validated core. It's on the application methodology. Okay.

And once we get that, we'll submit the safety analysis report.

MEMBER FORD: So material degradation issues, the only place it would come would be plant parameter uncertainties?

MR. RAO: Yes, but we have not done that specifically up yet. So I don't want to even imply. That will come in this, okay, in the safety analysis report. That's part of the next submittals.

So you'll be hearing about each one of these, and you'll see that chart come up a few times.

Okay. I'm down to almost one more chart after this, and basically we have simplified the design with passive systems. The plant evaluations are simpler. Calculations can be done at the back of an envelope of the containment pressure. You can look at what we've done in the design in terms of LOCA. We've added a lot more water to the vessel. That's why you don't uncover the core.

And we can take a lot of uncertainty, you know, injection rates, start times, VDCS flows, all of those things, and it's not a plant that's sensitive to any of those uncertainties.

The analysis is a lot less complex than in the past. What you'll hear, again, later on -- I'm just giving you an overview -- is that we're using the best test for AOOs. Okay? For the three applications here, we are trying to follow the procedure that's approved by the NRC or suggested by the NRC. We're using a best estimate cord with uncertainties defined as for our operating plants, the same as for AOOs for operating plants, no different procedure, no different application.

For ECCS/LOCA, since we had lots of margin what we did was we're using best estimate code with a simplified accounting of the uncertainties. It's a simplified accounting just to save us work because, you know, you can build the same procedures around 59 cases and do all of the uncertainties. All that you will get is, you know, ultimately there will be no change in the peak cladding temperature.

So what we've done is a simplified accounting of the uncertainties. It's just simplified. It's more, you know -- it doesn't seem to be evaluable, of any use to do all of those 59 cases.

MEMBER SIEBER: Are you going to explain exactly what you mean by simplified later on?

MR. RAO: Later on.

MEMBER SIEBER: Thanks.

MR. RAO: Okay, but I do want to tell you that, you know, there's a slight difference in the application of the TRACG out here and just give you a heads up. That's what you're going to hear.

MEMBER SIEBER: Okay.

MR. RAO: That's what issue we're looking for as we go through the presentations.

For the containment and LOCA, we're using a bounding calculation for the containment and LOCA analysis, and we've also accounted for the uncertainties, and we'll tell you how we've accounted for the uncertainties.

Primarily the key issue out here is how do you account for stratification and mixing. Okay? Like I mentioned earlier, there are two components that determine the containment pressure: how much air gets pushed into the wetwell airspace, and there's no answer. You take all of it from the drywell and push it into the wetwell. There's no uncertainty there.

The only question is calculating how much stratification and mixing you get in the suppression pool, and that will give you the vapor pressure. That's a smaller part of the total containment pressure, but it is the only one that will give you any variation. Okay?

You can always do a bounding calculation of the air being shoved over. Okay. So we will tell you how we've done the bounding calculation for that stratification. So that's where that bounding calculation refers to.

There's low parameter uncertainty, especially in the ECCS/LOCA. You know, the declining temperature you see.

CHAIRMAN WALLIS: That looks like orders of magnitude better than usual. I don't believe half of the PCT.

MR. RAO: The core doesn't uncover. It's the PCT that it doesn't matter out here.

CHAIRMAN WALLIS: It's so low it doesn't matter.

MR. RAO: It doesn't matter.

CHAIRMAN WALLIS: So this observation is

irrelevant.

MR. RAO: Yes, it doesn't uncover.

Okay. The substantial margins that exist in the design, they're using integrated code. This is what the ACRS has wanted for years. We've got that. It's here. We're using it.

And it's not a code that we just developed. It's been around for --

CHAIRMAN WALLIS: I'm surprised your management allows you to pay for these enormous margins, and usually it's economically beneficial to get close to some limit rather than having an enormous margin.

MR. RAO: Well, I'll explain.

CHAIRMAN WALLIS: You're now going to say that, "Ah-ha, but now we're going to operate the power by 50 percent or something"?

MR. RAO: No, no, no.

(Laughter.)

MEMBER SIEBER: That's tomorrow.

CHAIRMAN WALLIS: There must be something that you're going to gain by --

MR. RAO: This will get me in trouble. We developed the ESBWR in spite of management. Okay?

(Laughter.)

MR. RAO: Okay. The --

MEMBER SIEBER: And so your work is not done.

MR. RAO: No, no, no, no. There was a reason --

PARTICIPANT: They're going to see the transcript.

MR. RAO: That's fine.

(Laughter.)

MR. RAO: The issue really here is what is the right power level. Okay? And we chose this power level for two reasons.

We could have gone up -- in fact, when we chose this power level, it was -- the EPR had gone up with 1,700, the ABWR II had gone up to 1,700. Our feedback from the utilities was 1,400 is about the right power level. That was what the market was telling us.

The second thing was that 7.1 meter diameter. We felt comfortable with these margins, and again, remember when you're trying to bring a new product to market, you do have to have something that stands out, and having the additional margin, and hopefully it will help us get through the NRC review, the ACRS review a lot easier. Okay?

This is an important factor in the whole design, getting passed through this right here.

MEMBER POWERS: He's issued a challenge for you, Dr. Wallis.

MR. RAO: The challenge really is, you know, right here on this chart. Okay? This is really the challenge for all of us, is it's been a 15-plus year technology and design program.

CHAIRMAN WALLIS: That doesn't sound to me good. I mean, if it has taken so long, it suggests that it's a very difficult thing to do. I don't think it's a --

MR. RAO: No, it's not.

CHAIRMAN WALLIS: -- good thing to claim that it has taken a long time and therefore it's good.

MR. RAO: No, it's not. Part of the reason has been there has been no interest in the market. So, you know, we're from California and no wine before its time. No product before its time out here, and if we had got the SBWR certified, no one would say a word. Okay? It looks like there's an interest out here.

So it's not the right time. Okay? I'm not trying to imply that anyone do the same. It's an extensive technology program. Simplification is by design. It's not just my words. You can see the numbers. It's the design that's the issue.

The large vessel, you know, we -- by the way, the large vessel actually doesn't end up costing us much money. Just from a practical point of view, it's just an extra ring. The most expensive part of the vessel is the lower head. It's not the extra rings up at the top, and the --

CHAIRMAN WALLIS: All of those penetrations that you have down there is the problem?

MR. RAO: Yeah, that's what. You know with the pumps and all of that, that's the most expensive part, and just to cite the issue out here not for review is that the vessel height does not set the building height. It's different than the traditional boiling water reactors.

So the challenges for the coming months really are we need closure and confirmation, and one of the issues that the utilities put up in their presentations is regulatory risk, and this is one of the issues they say about the ESBWR, is you guys don't have a piece of paper to show to us that you can get closure on any of these issues.

That's why we have renamed this the technology closure program, not just the pre-application review. This is not, you know, just to get a feeling for it. We wanted to show that, yes, we don't need any testing. We can use the TRACG code and we've done a good job.

And thank you.

MEMBER KRESS: Could you go back to your slide number six? I don't know if you can back up or not.

CHAIRMAN WALLIS: Just don't click to exit.

MEMBER KRESS: Now, on your power flow map, yeah, could you show me at full power where you're operating? Right there. You don't have a MELLA line because that's a pump characteristic.

MEMBER SIEBER: Right.

MR. RAO: Right.

MEMBER KRESS: So you're operating right on that steep part of that natural convection line right there.

MR. RAO: Right there. This, you know, I'm trying to show a natural circulator and a forced circulator.

MEMBER KRESS: Yeah, I understand.

MR. RAO: That chart is kind of misleading. You've got to remember that the --

MEMBER KRESS: Yeah, I understand.

MR. RAO: This should be the X axis for the natural circulator.

MEMBER KRESS: Yeah.

MR. RAO: Because what it control --

MEMBER KRESS: It should be the other way around.

MR. RAO: It should be the other way around.

MEMBER KRESS: Yeah.

MR. RAO: But, you know, because people are used to this chart, we're showing it this way. This is -- you know.

MEMBER KRESS: Does that open up the possibility of small perturbations in flow giving you large perturbations in power?

MR. RAO: No.

Rob, do you want to answer that?

PARTICIPANT: No, because each point on that curve corresponds to a particular control rod position. As you pull rods, you get different points of operation. You cannot go from one flow to another. You cannot jump from one flow to another.

MEMBER KRESS: So this is not a natural thing. It's a control rod.

PARTICIPANT: Yeah.

MEMBER KRESS: I understand that. Okay.

Well, the question there then, another question on defense in depth, do you have more than one redundant system to shut down, scram (phonetic) the reactor?

MR. RAO: Yes. We have, in addition to the control rod drives, which are both electrically and hydraulically driven --

MEMBER KRESS: That's sort of a diversity, yes.

MR. RAO: That's the diversity there, and we also have a boron injection system.

MEMBER KRESS: You have boron injections. Okay. Thank you.

MEMBER SIEBER: That system would have to be quite large compared to the current BWR --

MR. RAO: The boron injection system is actually --

MEMBER SIEBER: High volume.

MR. RAO: -- an accumulator driven system.

MEMBER SIEBER: Right.

MR. RAO: It's a large tank, two large tanks actually.

MEMBER RANSOM: Where is the boron

injection system located? Is it outside the containment or --

MR. RAO: It's outside the containment. It's -- it's outside containment. It's up high.

MEMBER SIEBER: Yes.

MR. RAO: I can show you on the drawing in the break.

MEMBER RANSOM: By natural circulation, you mean, or do you have --

MR. RAO: No, no. It's a high pressure accumulator driven system.

MEMBER RANSOM: Okay.

MR. RAO: It's on natural circulation. It's accumulator driven. So it's high pressure injection.

Just it's not part of the review, but ATWS in this plant is handled at high pressure.

CHAIRMAN WALLIS: Any more questions at this time?

MEMBER SIEBER: Well, just one. Are you talking operating pressure and above when you say high pressure?

MR. RAO: Yeah.

MEMBER SIEBER: Okay.

MR. RAO: You don't need to depressurize

basically. You inject the boron. You remove the -- ATWS is a containment decay heat removal issue.

MEMBER SIEBER: Right.

MR. RAO: This one, we don't dump much into the containment. We remove it directly from the vessel to the isolation condensers.

MEMBER SIEBER: But the accumulators are probably 1,500 pounds or better.

MR. RAO: In other pressure or --

MEMBER SIEBER: To start.

MR. RAO: I don't know the pressure. I was going to say 2,000, but --

MEMBER SIEBER: Well, I was, too.

MR. RAO: Yeah. I think it is 2,000, but we can give you the exact number.

MEMBER SIEBER: Well, it's not that important. I was just trying to understand what it --

MR. RAO: Yeah. Well, it injects and it basically shuts down. The key question is where do you remove the steam. The way it works is initially the relief valve opens. It dumps some energy into the suppression pool, but very soon the isolation condensers take over and it can remove the energy, and so you stay at high pressure. You don't lose anymore boron out of the water.

MEMBER RANSOM: Atam, one other question on your containment pressure slide.

MR. RAO: Yes, sir.

MEMBER RANSOM: I don't know what -- it's page 11.

MR. RAO: Okay.

MEMBER RANSOM: Where does that eventually go and what eventually turns it around?

MR. RAO: You have a turn-around in an active system.

MEMBER RANSOM: Pardon?

MR. RAO: You turn on an active system long term to bring the pressure down. That's a large plot, you know. It's kind of misleading. It makes it look like it keeps going on.

MEMBER RANSOM: Do you have a table you can give to us of the volumes and the design, the amount of water and GDCS in the wetwell and so forth?

MR. RAO: We can try to pull that together.

MEMBER RANSOM: Yeah, I have the table.

CHAIRMAN WALLIS: I think it's time we put an end to this. It has been a very useful overview.

Thank you very much. I think it has helped us a great deal, and now we're going to dig into the details, but first we will take a break.

Since we have taken so long, I think everything is going to be moved up today by 45 minutes or an hours. We should just plan accordingly, and we should expect to be here until five or six o'clock and not to finish by 4:15.

We will take a break now until 20 minutes before 11, and I'd ask everyone to be back on time so that we can start at that time.

(Whereupon, at 10:25 a.m., a short recess was taken, reconvening in open session at 4:26 p.m.)

(Whereupon, the proceedings in the above-entitled matter went back on the record at 4:26 p.m.)

CHAIRMAN WALLIS: Back on the record. We'll now hear from staff.

MS. CUBBAGE: Thank you. I'm Amy Cubbage, Project manager, ESBWR pre-application review in NRR, and I'm going to give a brief discussion on the scope and schedule for the pre- application review. You've seen this earlier today, but I just wanted to make a couple of points here; one being that PRA is not included in the pre-application review scope. That will be addressed during the design certification review. And ATWS and stability are not in the current pre-application scope, but will likely be added in early `04 as an addition to the pre-application review.

And on the schedule slide, I'd just like to point out that the staff has provided 317 RAIs to GE at this point, and we're planning to issue additional RAIs by the end of the month.

MR. POWERS: Do you get paid by the RAI, or --

(Laughter.)

MS. CUBBAGE: Around 300. Is that better?

MR. POWERS: Maybe these guys can work a deal and pay you more for non-RAIs.

MS. CUBBAGE: I'm afraid it doesn't work that way.

MR. POWERS: Oh, all right.

MS. CUBBAGE: Research and NRR have developed a pre-application review plan, and assembled an inter-office review team. Ralph Landry has the lead for the TRACG review. Muhhamad Razzaque will be presenting the Tab D Scaling and Testing Review, and Joe Staudemeier from Office of Research will discuss the research activities associated with the SBWR. And if there are no questions, I'd like to turn it over to Ralph to get started.

CHAIRMAN WALLIS: Well, we're going to have research activities later?

MS. CUBBAGE: Correct.

CHAIRMAN WALLIS: It seems as if we've gone into a situation we've been in before, where research comes after it's needed.

MS. CUBBAGE: Oh, later meaning in this presentation.

CHAIRMAN WALLIS: No. I mean research is going to be done after NRR has made some of its decisions.

MS. CUBBAGE: There are some activities that are in direct support of the pre-application review, and we'll discuss those. And then there are other activities that will be in support of the design certification.

CHAIRMAN WALLIS: But even those you're going to have to hustle.

MS. CUBBAGE: That's right.

CHAIRMAN WALLIS: Okay. Sorry to stop you. Go ahead, Ralph.

MR. LANDRY: I'm Ralph Landry from NRR, Reactor Systems Branch. And this afternoon, I'm going to try to get through this fairly quickly. Most of the material has been touched on already, but I would like to give a view of the staff over some of these points. And I'm going to go through very quickly the TRACG Code Review approach, who the team members are involved in the review, a few of the technical issues which have been raised. And on these issues, we don't have answers yet. These are some of the points that we've raised as concerns, and points that we've asked in RAIs and are seeking to have addressed, a little bit about the status of the RAIs, which Amy has just mentioned, talk about some of the confirmatory calculations that we have planned and that are underway, and a few of our conclusions.

The approach that we've taken to the review of TRACG is two- pronged. One is reviewing the documentation, and the second part is going to be reviewing use of the code, analysis and performing of confirmatory calculations.

Looking at the documents today, we've been looking at the TRACG model description, VIA's BWR application qualification, the SBWR application and qualification and the input manual to the code. The code documentation is fairly good. Looking at all these different codes over the years, we've seen some documentation that's been abysmal and that's kind. We've seen some documentation that's far better.

The frustration we've had with this documentation is the breadth of it. We began looking at the model description document, which is noted as Revision 2. It's the same volume that was submitted for AOO reviews of TRACG. We were told that's the document we're supposed to review for the model description for TRACG part of this application. Well, in performing that review, we found out that where's all the containment stuff? This code is being used for the reactor coolant system and for the containment, but there was nothing in there applicable to the containment. OG said you have to back to Rev. 1 of the document, the SBWR version, to find the containment material, so we went back to the Rev. 1 to find that the containment relevant material, but it's all relevant to the SBWR containment.

Then we said well, if we're going to look at that, we have to go back and compare it to Rev. 0 to see what corrections were made, to see if they updated as had been planned in the SBWR review. So the frustration is, while we say we're looking at the model description document, we're actually looking at three volumes, three revisions of the same document, and that material still isn't complete, and has resulted in RAIs.

Looking at the description material, we found a number of places where there are typographical errors. There are equations where something as simple as gravity has been left out of the equation. We found in one of the figures in Section 6.6, units which we have been trying to figure out what the meaning of the units are. We found a figure that has the units of walls per meter square per degree kelvin, and we kept -- I don't know if it meant Wallises.

CHAIRMAN WALLIS: Watts.

MR. LANDRY: It meant Wallises per meter

squared. We have yet to figure out what a wall is, so these are the kind of errors that we're finding that you would expect in Rev. 2 to not see things like this.

The analytical review has been to run the TRACG code as we received it from General Electric with the SBWR input model. We have their input --

CHAIRMAN WALLIS: Are you running their code?

MR. LANDRY: Their code with their input deck. I'll give you some results from that run later.

CHAIRMAN WALLIS: Does it run better than TRACM?

MR. LANDRY: I'm not addressing that. We've been running TRACG, looking at some analyses and some test cases, and we intend to do confirmatory analyses using the contained code, look at the containment part of the plant design. We want to use TRACM TRACE. Sometimes I use TRACM, sometimes I call it TRACE. I haven't gotten used to the name change yet.

Then we want to look at a couple code, coupling TRACM with CONTAIN. We're doing this because we looked at the code and said okay, they're using one code to look at the reactor coolant system and the containment.

CHAIRMAN WALLIS: It's actually TRACE. It's the predecessor of TRACG.

MR. LANDRY: I think this is degenerating. We looked at the code and said you're using one code to do both the reactor coolant system and the containment as one coupled continuous calculation. We're not so sure about that.

What we would like to do is convert the TRACG deck as it stands to run in TRACM. Well, for comparison, here's a code of a similar lineage, some differences. What would happen running the same model on both codes? Well, the TRACM has some problems with some of the aspects of the containment, so we said okay, we can't do that. So what we're going to do is we're going to take the TRACG input deck, disassemble the deck. In other words, the reactor coolant system, the containment. We're going to take the containment and input it to CONTAIN. We're going to run a stand-alone containment model.

Then we're going to run the converted reactor coolant system model from TRACG with TRACE, and then we're going to bring those two codes together, which the coupling has been done now. And so far we've gotten a run out to, I think it's 120, 150 seconds. But a combined calculation of TRACE and CONTAIN so that we can see, does the reactor coolant system with a realistic containment code give a result similar to the result you get with TRACG running both the reactor coolant system and the containment in one code. This is an approach that we're taking to these confirmatory calculations.

MR. POWERS: When you say similar, is that something that is in the eyes of the beholder? Will I know it if I see it, or is there --

MR. LANDRY: Yes.

MR. POWERS: -- criterion for what "similarity" means?

MR. LANDRY: Right now we don't have criterion other than we want to see what the results are first, and are there differences, and then why are there differences, if we see them? And what is the magnitude of the differences, and what is the significance of them?

MR. POWERS: Take something that's easier to think about like suppression pool temperatures. They have very mild suppression pool temperatures in their calculations they showed today. What magnitude of difference would cause you pause?

MR. LANDRY: At this point we haven't tried to figure out exactly the magnitude of what -- because we're just at the very infancy stage of this process.

MR. POWERS: I understand. But I mean your experience now.

MR. LANDRY: Right now we're so focused on trying to get this to run, that we haven't gone back and said magnitudes can we tolerate.

MR. POWERS: Well a lot of my motivation for asking this question is because it's such an onerous undertaking that you -- what I would like to understand, is it a matter of seeing differences of say 20 degrees, or is it a matter of seeing the suppression pool get up to the point that it's closing in on saturation?

MR. LANDRY: That would give us pause.

MR. POWERS: That would give you pause, I know.

MR. LANDRY: Definitely.

MR. POWERS: Would the other one, 10 or 20 degrees, give you pause?

MR. LANDRY: Ten to twenty probably isn't going to give us a great deal of concern.

MR. POWERS: Okay. I understand.

CHAIRMAN WALLIS: Now TRACG has been run a lot of times, and TRACE has hardly been run at all, so really you be perhaps testing TRACE rather than TRACG.

MR. LANDRY: Well, TRACE has been run a fair amount, and we're running it with a converted input model.

CHAIRMAN WALLIS: So it has --

MR. LANDRY: Plus, it's being assessed by research. Research is doing a lot of work. Very vast for us.

CHAIRMAN WALLIS: Okay. It has a history of actually being able to model BWRs and so on?

MR. LANDRY: Yes. They're working on that, and working on comparisons. You'll hear more about that from Joe Staudemeier later, but they're working on a lot of assessment of TRACE versus not only the test that General Electric has referred to, but also the --

CHAIRMAN WALLIS: Okay. So we will hear about that.

MR. LANDRY: Yeah. You'll hear more about that from Joe.

The range of the review, Amy has already covered. We're looking at LOCA, ECCS and containment performance with TRACG at this point. We are not looking at in the pre-application review transients, ATWS or stability. Those points are going to be brought up later.

The people involved in the review are myself, Shanlai Lu, Ed Throm and Andre Drozd, all from NRR. It's a combination of reactor coolant system analysts and containment analysts. We have contracts with Brookhaven National Laboratories, ISL and Oakridge to support us in the work.

Research has a team together, including Joe. Joe Kelly is involved in it, Steve Bajorek, Jim Han. Let's see, Kodak is involved in it. Al Notofrancesco is involved in it. I think Dave Bessette is involved in the work, plus they have contractors. So it's a fairly large group of us involved in it, but very limited focus pre-application review. And you have to emphasize this. This is a very limited focus review at this pre- application stage. It's only on the code.

Some of the technical issues which we've raised so far, and these are all in the RAIs, we're concerned with the way reactor power is handled in an accident and the analysis. We see no delay in reactor SCRAM. Break initiates, reactor is SCRAMed instantaneously. No four to eight second delay that you normally see in a SCRAM.

What is that going to mean for some of these breaks and the amount of power? We're concerned about some of the mass and energy release through the break and through the ADS. We've asked questions about critical flow through valves, and the way it's model. Virgil has already asked that question. We're not going to the point that Virgil was asking, but we have asked questions in that area already.

We're concerned about the PCCS performance, and we're studying that performance since it is such a critical system. Gravity draining and the interfacial heat transfer and flashing we've asked questions about.

Some of the modeling issues that we've raised, include the use of a single vessel model for both the reactor coolant system and the containment. This is one of the problems that TRACE has, that you can't use a single vessel for this entire system. We're concerned as an extension of that, with the thick heat structure that's around the vessel for the main steam line break LOCA.

They have the reactor coolant system, they have a containment, and they have our heat structure this wide between the two, but that number is proprietary. Well, we're trying to figure out where in the world it exists in reality. We don't know. We can't find it.

CHAIRMAN WALLIS: What do you mean by heat structure?

MR. LANDRY: A heat sink, a heat slab, something that energy is absorbed by.

CHAIRMAN WALLIS: You mean a slab of concrete?

MR. LANDRY: We can't find what it is. We're concerned about radio distortions in their model. Gravity is distorted, and we're concerned about non-condensible distribution, questions which you've already raised today.

MR. RANSOM: How is gravity distorted?

MR. LANDRY: The way the friction is modeling, but Shanlai. (4:42:20)

MR. LU: Okay. I am Shanlai Lu from the DSSA. We are currently looking at gravity and parameters produced and the heat remaining from a UCCS LOCA. The pancake will be contained, and part of the vessel in terms of delivering it all together, and use it as one single TRACG vessel model, the model into our system. And we are trying to look at that to see whether numerically, because if you do have let's say layer 21 to lay 31, is way above the reactor vessel itself. Then numerically the pool is really high. You have the elevation difference between the pool and the reactor vessel itself. However, we tried to use the TRACG, the one component compensated this part to take into account the current that the gravity failure had. So what we're trying to do is trying to verify this, so this is correctly done. That's what we're trying to do.

MR. RANSOM: I guess that's quite dangerous if you have any loops.

MR. LU: Yes. That's a reason we want to look into that, because if we go back to return PFM, the stage, we have disconnected the elevation of the loop, and the loop closure is not closely closed then. You will have a problem with gravity.

MR. SCHROCK: Ralph, I don't know what TRACE is.

MR. LANDRY: TRACE is TRACM.

MR. SCHROCK: TRACE is TRACM.

MR. LANDRY: TRACM has been renamed to TRACE. That's why I said, I keep going back and forth, referring to TRACE or to TRACM.

Some of the technical issues that we've

identified with the transients, even though we're not reviewing the transients at this point. The incorrect core design, you've heard this morning that GE talked about using a nine foot core when it's actually going to be a ten foot core. Well, that's true of the LOCA analyses also, and we've raised the question, what are the fuel design parameters for this core?

They were supposed to have that information to us last November. We're almost to the middle of July, and we have yet to see it. We have a contractor waiting to generate the core parameters for us when we get that data from GE.

We're concerned about stability, and in particular, stability of a pancake core. This core is shorter and larger in diameter than typical. Those of us that have been involved in past reactor work in the past know that when you pancake a core, you create a core that is less stable than a tall thin core.

CHAIRMAN WALLIS: Is this from a neutronics point of view?

MR. LANDRY: Neutronically it's less stable, so we're concerned about the stability of this core, since it's being pancaked.

We're concerned about adequate heat transfer data for the fuel design. The question was raised this morning about are we getting in the same situation we were in with the GE 14 data, and the Drexell-14 correlation? And we've identified this concern to General Electric 14 because of inadequate data. They're supposed to be obtaining those data this summer, but this is an extension of that problem.

We have over 300 RAIs outstanding at this point. We've asked 317, some of them have multiple points, parts to them. It's many, many pages. They range from modeling issues to typos. We've had a number of telecons with General Electric. We've had meetings, and we're going to have an all-day meeting tomorrow with them reviewing the status of some of these RAIs, and their responses to them.

The formal RAIs are due out the 18th of this month, so we're pressing to conclude our RAI set so that Amy can get those RAIs issued. Those responses are due in August. If we're going to meet the schedule that we're on today, which is an extremely aggressive schedule for this SER, there cannot be any slip in getting those responses. Now we've indicated that a couple of times. Any slippage at all, and it's just going to be impossible to meet the schedule that we're on.

The confirmatory calculations that we are performing, as I've said already, meaning running the TRACG SBWR input deck on TRACG. We're running contained input model. Some of those runs have already been done. Those are using mass and energy data generated by TRACG, and we're generating data now with TRACM, TRACE, TRACM, whichever name you want to use. Input model has been developed in conjunction with research, and with ISL. And I'd like to note that research has done an incredible job of helping us with that problem. They've put a lot of effort into it, debugged the code, debugged the input model, and put a great deal of effort and a great deal of support into helping us with that model generation.

TRACE-CONTAIN linkage is underway. It has been linked, and the initial runs have started, we're hopeful to have some good confirmatory calculations in the not too distant future.

This table lays out a number of the calculations that we're performing. These are the major blocks, of course, all the sub- calculations performed. But you see the initial GDCS and main steam line break calculations with TRACG we've completed. We're still studying the results. We've started doing some PCCS calculations with TRACG. We're looking at calculations to study energy conservation in TRACG, some calculations for gravity flow. The main steam line break LOCA has begun with CONTAIN. Some of those calculations have been performed. The TRACE-CONTAIN link has been initiated. We're going to look at GDCS LOCA. The GE-12 fuel, that's what I alluded to that we need the fuel information. We're waiting to get the information on the fuel so that we can have Oakridge National Laboratory generate the fuel parameters for us.

AOOs are planned after we get the correct fuel model, and when we start into the transient review phase, and we will probably do some of those calculations with a linked TRACE part, so we can get the 3-D core neutronics effects into TRACE also.

MS. CUBBAGE: Virgil, she's trying to get you to use your mic.

MR. SCHROCK: Excuse me. How much do you know about this new reactor core? I mean, when we were looking at the uprates, we learned a lot about the -- were exposed to a lot of information about the non-uniform --

MR. LANDRY: Six parameters for us, so that we can do a 3-D neutronics calculation that is more representative of this core. If you remember when we did the AOO review on TRACG, we did a lot of calculations looking at the neutronics of the TRACG model versus the neutronic feedback, or neutronic response running TRACB with NESTLE and with PARCS. And we feel very strongly that the response to a number of the AOOs is highly dependent upon the core design. And we cannot do that with a core that is not the right core.

The present core is not the core going in this plant, and we will not do calculations and spend our money and waste our time when we don't have the right fuel design.

This is the result -- you saw results from General Electric of GDCS LOCA earlier. This is what they -- this is something that they did not show you. These are results from our calculations, their code their input deck, running under the same operating system, same class of computer, so the results should be -- they should be getting these results.

If you look at the GDCS pool, if you look at the wet well, if you look at the difference in pressures between the air spaces, this is a question that Graham asked earlier. You have an airspace above the GDCS pool, you have an airspace above the suppression pool. They're connected by three pipes that are half a meter in diameter. Why are those pressures different? We look at that and start scratching our head. These are fairly new results. We're scratching our head looking at it and thinking first, well, maybe it's a numeric problem. And then we started looking at it more and saying no, we don't think it's a numeric problem. We think it's a lousy modeling problem. We think it's a very poor normalization problem. If we look at the normalization, what we see is in the GDCS, if you look at Chester's figures on his page 5, the GDCS airspace pressure is not the airspace pressure. It's the center of the cell pressure. It's the pressure of the air plus half of the waterhead. Waterhead gives you pressure of half a PSI per foot.

You start measuring three, four, five feet, you start changing your pressure by quite a bit. This problem is what happens if you don't nodalize correctly, and don't pay attention to the nodalization of your plant. Those two volumes should not be at different pressures with three pipes that are half a meter in diameter connecting them.

CHAIRMAN WALLIS: The code is putting water in there where there is no water?

MR. LANDRY: No. The code is measuring what is supposed to be the air -- what is being output as the airspace pressure, is not the airspace pressure. It's the airspace pressure, plus the pressure head from half of the water that's in that volume.

CHAIRMAN WALLIS: Well, why would you add that water pressure?

MR. LANDRY: Because that's where the pressure is being taken at the center of the cell. The center of the other cell has no water in it.

CHAIRMAN WALLIS: It's just not physical.

MR. LANDRY: Right. That's what I'm saying, it's not nodalized correctly, so this is --

MR. FORD: Have these differences been discussed with GE, and they're just a question of different analysis of this, or difference in communications?

MR. LANDRY: They didn't say anything about this to us, and this -- we were looking at this and trying to figure out what's going on. This is just in the last couple of days that we've been looking at it, and putting together what we see going on.

MR. FORD: Well, it's really not fair to castigate them when they haven't given a reply to you.

MR. LU: Initially -- we have been

corresponding to GE regarding this, and the real issue here is, we were trying to see whether it conservatively predicted the mass, the non-condensible mass above the GDCS pool, see whether it would give the conservative water level at the end of the GDCS LOCA.

CHAIRMAN WALLIS: Anyway, what this shows is that when you run their code, you can find things which you have to question.

MR. LANDRY: That's correct.

CHAIRMAN WALLIS: All right. And this was an example of that.

MR. LANDRY: That's correct.

CHAIRMAN WALLIS: It doesn't show that this issue has been resolved in any way.

MR. LANDRY: Right.

CHAIRMAN WALLIS: It's an example of what can happen.

MR. LANDRY: This just adds further support to the staff's view that we have to have the code and the input models of applicants so that we can do our own confirmatory calculations, we can do our own investigations. If by doing our own investigations we're able to plot some parameters that we weren't seeing in the submittal, when we plotted some of these parameters, we said what's going on here? We don't understand this. So it's just further support for the position of staff that we need the codes, and we need the models so that we can do our own studies.

MR. BANERJEE: Is that little blip a vacuum breaker?

MR. LANDRY: I don't know what that is at this point. This little spot, I'm not sure at this point. We haven't gone that far. It would not be changes made in the design that would challenge the capability of the code.

MR. POWERS: A change in the core height by a foot represent a pretty dramatic change?

MR. LANDRY: Only if there are features in the fuel design that were not modeled in the fuel design capability of the code. If you had a core model that could not handle water rise for some reason, and you designed fuel -- and you put fuel in that had water rise, could you model that? Or could you fix the model so that it would? The height alone, I would not see how height alone would call it into question, unless there was something extremely restrictive in the neutronic capability of the code that it could not handle that change in neutronics.

Does that answer your question, Dana? Thank you.

CHAIRMAN WALLIS: This is a very restrictive thing. We heard this big presentation this morning about how wonderful this reactor was, and that's irrelevant. Everything that we're looking at, you're looking at here is whether on TRACG is adequate for analyzing this sort of a system. This has nothing to do with how good a design it may be, and all those things we heard about this morning. Simply the adequacy of the code which is being assessed here.

MR. LANDRY: That's correct, Graham. And that's why I tried to say that this is such a very focused review, because it is very focused. It's focused very strictly on the code applicability.

CHAIRMAN WALLIS: Do you look at things like this Ontario Hydro Test, and make your own assessment of it?

MR. LANDRY: We're looking at the --

CHAIRMAN WALLIS: All these other tests?

MR. LANDRY: We're looking at the assessment. We don't have the Ontario data, but we're going to try to get that data too, to look at it ourselves.

MS. CUBBAGE: Okay. Muhhamad.

CHAIRMAN WALLIS: Well, from my own

perspective, I haven't had time to look at this extensive documentation you referred to, Ralph. I'm just a little nervous about what I may find when I do.

MR. POWERS: Don't look at it then.

CHAIRMAN WALLIS: See, that's the traditional advice from the more experience ACRS Member than I am.

MR. POWERS: No, I make that no claim as good advice to you. I only say that that will ease your fears.

CHAIRMAN WALLIS: You're being facetious, I think.

MR. RAZZAQUE: The team that is involving the review of the Tab D testing and scaling are myself, Andre Drozd of NRR, and from research side we have Jim Han, David Bessette, and supporting is ISL.

This slide I basically identified some of the -- we identified some of the significant RAIs that we have issued so far. Again, the number of RAIs are large, and it ranges from simple typo to some significant issues regarding scaling and testing. We may sent some of the RAIs in detail, but this is basically in the brief title sort of thing. So I'll just quickly go over them, unless you have some more question, and elaborate any of those.

The first one is obviously one question raised during the meeting, was about scaling. The higher tier, two-tier scaling methodology which was used for the scaling analysis requires that you use both the top down and the bottom up approach. GE's report heavily relied on the top down approach, but very little on the bottom up, so that's the purpose of that question. The particular quantitative bottom up analysis --

MR. SCHROCK: Well, they offered some preliminary, at least, reaction to that. Were you here? Did you hear what they said?

MR. RAZZAQUE: Yes. Yes, I did.

MR. SCHROCK: And that isn't sufficient?

MR. RAZZAQUE: We'll have to -- actually, I haven't seen the information that's given on SBWR report. In the SBWR report, it was almost non-existent, but I will have to go and review the ESBWR portion and make sure that we are satisfied with it. But primarily, the question was that they're heavily relying on the quantitative top down approach, very little on the bottom up approach. That's basically a different side. It may be adequate, maybe the case can remain, but that was one question.

CHAIRMAN WALLIS: Did you have an RAI on

this assumption that any doubts of LG is the same in the model and the prototype?

MR. RAZZAQUE: Which --

CHAIRMAN WALLIS: It seemed to be an assertion with no basis in the scaling?

MR. RAZZAQUE: Which?

CHAIRMAN WALLIS: In the condensation, phase change. They had some assertion that NLG, the phase change per unit area was the same in the model and the prototype, and therefore, to get the same mass, you had to have to scale the areas in some sort of way to get the flow rates right. There doesn't seem to be any basis for this assertion that the condensation rate was the same in the model and the prototype.

MR. RAZZAQUE: You're talking about the PCCS?

CHAIRMAN WALLIS: I was talking -- just the top down scaling.

MR. RAZZAQUE: Oh,

CHAIRMAN WALLIS: That seemed to be -- otherwise, it seemed very simple. I mean, it seems that the lengths have to be the same and various things. And this assertion out of the blue, that the rate of phase change, the phase change flux was the same in both systems. What justification is that? I'm just wondering if you have an RAI on that issue, that's all.

MR. RAZZAQUE: I'll have to go and check. I didn't -- I just picked a few for presentation. I'll have to double check that. And maybe we have an RAI on that. That's almost a bottom up.

CHAIRMAN WALLIS: It is, yeah.

MR. RAZZAQUE: Rather than a top down issue.

CHAIRMAN WALLIS: What's the justification?

MR. RAZZAQUE: Also, I think as part of the -- part of the RAI indicates that linking some of the phenomena that has been identified from the bottom up and top down to the part, that link should also be made more thoroughly.

The next one was the PI-Groups which is the groups for the three test facilities. GE has relied on these test facilities to qualify TRACG code. They have indicated that. The boron mixing is for the ATWS, and the criterion for the stability test. They have indicated that they used those facility data to qualify TRACG.

Now in the scaling report, or any other

reports that we're reviewing, I haven't seen any comparison of ESBWR versus these facilities scaling groups, to make sure that these facilities truly can represent the ESBWR design. In other words, can be scaled out, so that's another RAI. So they will have to provide that information.

Impact of potential distortion bias due to heat loss. That's another question I think raised sometime during the discussion, the heat loss. And that RAI is out, and particularly in GIRAFFE facility I think it should be more significant compared to other facilities, because some of the GIRAFFE test was done at operating temperature and pressure, whereas the vessel wall is thinner, so more heat loss. But as Bob Gamble has indicated, they have done something about that in putting micro heaters to offset that. So those kind of descriptions have to be provided to justify that measure taken to offset the distortion.

The last one on this bullet here on this slide also is another test distortion-related RAI, which is relatively minor as my understanding is, but still it's a distortion. And the PANDA and PANTHER's condensers that they have used are full scale, but the number of condensers they used are fewer; therefore, the head area is smaller in the test.

Now when you scale that up, the surface to volume ratio would be less in the ESBWR; therefore, less heat loss through the headers. So it will have some impact on the containment pressure. And the report mentioned that, but didn't quantify it, so we wanted them to quantify that just to make sure.

MR. BANERJEE: That's for PANDA. Right?

MR. RAZZAQUE: That's for PANDA and PANTHER.

MR. BANERJEE: PANTHER is a stand-alone system, full scale, isn't it?

MR. RAZZAQUE: Yes. Both PANDA and PANTHER's condensers are full scale. But since it is --

MR. BANERJEE: PANDA is a slice, so it has end walls on the headers which are potentially sources of heat loss.

MR. RAZZAQUE: Right. Right.

MR. BANERJEE: PANTHER is a stand-alone facility just to look at the heat transfer. So how does that affect --

MR. RAZZAQUE: What I'm basically talking about is that when they were testing the condensers, the heat removal capability of the PCCS condensers, they have a header, common header. In the test facility, the header volume is smaller compared to the ESBWR header, because the power is less.

MR. BANERJEE: Certainly, for PANDA. But for PANTHER, I thought it was just a full scale -- maybe for the SBWR it was full scale.

MR. RAZZAQUE: For ESBWR, yeah, it is.

MR. BANERJEE: SBWR.

MR. RAZZAQUE: SBWR maybe it is full scale, but for ESBWR --

MR. BANERJEE: It's only a 25 percent difference.

MR. RAZZAQUE: Yeah. The power is definitely much less than the SBWR power, so they used three wall condenser.

MR. BANERJEE: Sure. Yeah, but poor condenser -- I don't get the point about the PANTHER. I get the point about the PANDA.

MR. RAZZAQUE: Okay.

MR. BANERJEE: I don't know what the question is there, actually, regarding PANTHER.

MR. RAZZAQUE: Okay. They basically should be the same question. Maybe it applies more to the PANDA, but the whole idea was the header being small in the test compared to the ESBWR. We have a scaling of the header, not the condenser.

MR. SCHROCK: PANTHER was a full scale --

MR. RAZZAQUE: Full scale system.

MR. SCHROCK: -- condenser typical of SBWR.

MR. RAZZAQUE: Right. But I think the number of condensers used was fewer in the test facility than the ESBWR to remove the same amount of -- the higher amount of power that ESBWR has.

MR. SCHROCK: Is that right?

MR. RAZZAQUE: Isn't it? That's my understanding.

MR. BANERJEE: It's slightly bigger.

MR. GAMBLE: It's a components test.

MR. RAZZAQUE: Yes, you have --

MR. GAMBLE: The header is 35 percent shorter than the ESBWR.

MR. RAZZAQUE: Yes, that's more likely.

MR. GAMBLE: It's primarily a PANDA issue.

MR. RAZZAQUE: Okay. This more applies to PANDA issue. Okay. So that's basically the question. When you scale the header up, you have -- but discussion with GE on that, the impact should be 5 to 10 percent on the peak cladding, and that was their rough estimate off-hand, so it shouldn't be a big effect.

The heat in the containment, that's the other distortion question that we have, is none of the testing that was done, the sole heat in the containment was considered, and what impact it has on the containment parameters.

Intuitively, of course, it will have some non-conservative effect on the short term in the containment pressure. And in the long term, it's not very clear which direction it's going to affect, conservative or non-conservative, so we wanted them to have some discussion and assessment on that, effect of stored heat in containment structure on the containment parameters, particularly the containment pressure.

The next RAI is reactor pressure vessel containment and dynamic interaction. We know that's the case in real situation in any transient accidents. Whereas the scaling groups, the scaling numbers, the PI numbers, those were derived based on a single differential equation, first order differential equation in time. And the question we're asking is did you look at the system of equation, a couple of system of equations in deriving the scaling groups from that, and see how that affects. The case may be made that a simplifying assumption is valid, but it wasn't made. The case wasn't made, so that's the other question.

In vessel nature of circulation effect on flashing. Flashing was found out to be a significant phenomenon in the reactor pressure vessel, not particularly an effect on the water level. What impact natural circulation within the vessel heads on that particular phenomenon? That's the question, and Ridge Scaling Group represented that in-vessel natural circulation. That was missing again, so we wanted to have some understanding which scaling group represent that natural circulation within vessel, and its impact on flashing, because flashing is an important phenomenon. Maybe it can be ignored, but it wasn't -- the case wasn't made.

Now in dimensional groups criteria range, this had to do with the PI-Group numbers. The PI-Group that has been derived for the test in the ESBWR has been compared in the table. And as long as those PI-Groups are within one part to three, it was considered acceptable. But the range -- the criteria they used, GE used to be acceptable is as long as the PI-Group numbers are within one part to three, but no basis provided where that criteria came from, where that range came from, one third to three. How do you know this is acceptable?

MR. KRESS: Traditionally, we've been using .5 to 2.

MR. RAZZAQUE: Five to two?

MR. KRESS: Point five to two.

MR. RAZZAQUE: Point five to two.

MR. KRESS: We didn't bless that. We question that.

PARTICIPANT: I don't think they had a basis --

MR. KRESS: No, there was no basis for it. It's just -- intuition was the basis.

MR. POWERS: AP1000 establishes a tradition.

MR. BANERJEE: Well, most of the scaling studies end up showing there's only one or two PI-Groups which are of any importance anyway.

MR. RAZZAQUE: In which case?

MR. BANERJEE: In any case, so if those are such that the response of the system is similar, and you can probably do that on the back of an envelope, then that's probably good enough. The rest of it doesn't really matter.

MR. RAZZAQUE: Yeah. Particularly, the PI-Groups which impact the figure merit. I mean, there should be some link that how the change of the PI-Group impact the figure of merit, which supposedly the --

MR. KRESS: That's the right idea.

MR. RAZZAQUE: Right. And there should be some --

MR. BANERJEE: There are very few which do, in fact.

MR. RAZZAQUE: Maybe very few, but at least very few those should be done. That way it gives some comfort level that you didn't just take from air, and there's some link with the scaling group, with the code qualability. That's the argument objective.

MR. KRESS: We thought you could actually do them analytically, just vary the parameter and see what it does.

MR. BANERJEE: In fact, that was what was done for AP600.

MR. RAZZAQUE: I wasn't involved with AP600. I don't know what the response was.

MR. BANERJEE: Solution to the lump parameter equations.

MR. RAZZAQUE: Okay. But it may be possible to do some linkage with key scaling group to the -- maybe here it's the water level we're talking about.

CHAIRMAN WALLIS: Well, you can always run TRACG with the model.

MR. RAZZAQUE: So we'll have to see how -- what GE responds to that.

CHAIRMAN WALLIS: And then you can do tests with parameters. You can say okay, let's run TRACG with the real scaling, and then let's run it with the actual model scaling and see if it's sensitive to --

MR. RAZZAQUE: That's right. I mean, it's possible -- it's not that you have to just intuitive, or without any basis. I think there can be some calculation done if one wants to, about how important it is, and maybe it should be important at least for doing one or two.

MR. BANERJEE: But if they reduced the master equation to one, they seem to be going in the right direction. They just have to justify that and show whichever is the appropriate scaling group, and that's it.

MR. RAZZAQUE: That's basically what we're saying. Maybe, as I say, the simplifying assumption may be valid, but the case wasn't made.

CHAIRMAN WALLIS: Right. So they have to show that.

MR. RAZZAQUE: They have to show that.

CHAIRMAN WALLIS: Yeah.

MR. RAZZAQUE: Exactly. The last bullet there is really regarding the quality assurance of the tests, whether the tests meet Appendix B Quality Assurance that NRC has. Primarily, the test which they have saved, they are using for confirmatory purposes. There are a few tests - I have the name here. One is PANDA P, another is SIRIUS, at the facility in Japan. Those test data are being used for confirmatory in nature. That's what the term appears in the report, "confirmatory in nature". What exactly that means? What the confirmatory in nature encompasses? And if you're relying on that data to qualify the code, TRACG code, or certify the design, it should meet all the Appendix B requirements. What you call it, confirmatory in nature or not. So that's that question. That's basically, as far as the scaling and the last bullet was not quite scaling. It was more of an Appendix B question.

These pages here regarding the Tab D and PARC questions. The first one is TRACG analysis for the bottom drain line break. They have provided main steam line break. They have also provided the gravity driven line break. As far as the bottom drain line break, what we're interested is in more detail, long-term containment parameters. That's what was, I think, missing.

The next bullet is TRACG comparison with PANDA PCS data. That comparison was given, but mostly for the containment parameters, not for the reactor pressure vessel parameters, like pressure and the water level. So we want to see that comparison, TRACG comparison with PANDA P reactor vessel parameter information, pressure and water level.

MR. BANERJEE: But they didn't have much of a reactor vessel. Right? In PANDA, they had a little thing just generating some steam. It wasn't a typical reactor.

MR. RAZZAQUE: Yeah. Maybe they can provide the pressure. I don't know.

MR. BANERJEE: It was -- if you look, they chopped it at the bottom. Right?

MR. RAZZAQUE: The author of the RAI, Dr. Han -- Jim, could you help me out on that, what exactly you want.

MR. HAN: Okay. Basically, as you know, the PANDA P series tests are the only tests that half the ESBWR configuration, so those tests are important to us. When GE compare the certain parameters in their report, the comparison is only limited to containment parameters, such as drywell or wetwell pressure. We would like to see in addition to those parameters, like reactor pressure vessel pressure and water level. PANDA does have a reactor pressure vessel.

MR. BANERJEE: But it's short, right?

MR. HAN: Short, doesn't matter. We'd like to know the pressure. We'd like to know the water level. And in addition to that, we also would like to see the comparison on suppression pool water level.

MR. BANERJEE: Right. The reactor pressure vessel is totally atypical. It has very little -- I mean, it's just a generator.

MR. HAN: Well --

MR. BANERJEE: I may be wrong, but perhaps General Electric could answer whether -- I thought it was chopped off at the bottom.

MR. HAN: It's chopped off only at the bottom.

MR. BANERJEE: Right. George Adagaramneu did these tests of PANDA, and he showed me this facility, and it was just a little thing.

MR. RAO: The reactor part -- the vessel part is not representative. He didn't think there was any meaningful data to be obtained from the reactor vessel. It's basically a containment test.

MR. HAN: Well, how about the pressure, for example, because you have to know the reactor system pressure, what is the driving force? Which right -- as you said, right on the wetwell pressure, we would like to see the difference.

MR. RAO: It's starting at very low pressure.

MR. HAN: I know, but we would like to see the difference between the reactor pressure vessel pressure --

MR. RAO: Okay. All right. I mean, we can provide the data. It's not clear to us why, but if that's what you want, we can provide it.

MR. RAZZAQUE: Okay. The next RAI is on the TRACG agreement comparison with GIST data. The question is basically, the result has been provided, and the result shows that the more recent version of TRACG agrees much better with GIST data than the older version of the TRACG. And the question is, what are the difference -- what change is there, model change, or modem change or what? We just want to understand that. That is the other question.

The last one there is a comparison of important RPV and containment parameters for counterpart integral test. There are several counterpart tests that was done, PANDA M-3, PANDA P-2, and GIRAFFE H-1, and we want to have a comparison of these tests, because these are integral tests and how to compare each other would be of help because of the different scale size. So that's the other information that we requested from GE.

CHAIRMAN WALLIS: Now you have some conclusions here.

MR. RAZZAQUE: That's the last section, and --

CHAIRMAN WALLIS: I think we can probably read those. What I want to know is, you've sent out a huge number of RAIs. And have you gotten responses to these RAIs?

MR. RAZZAQUE: No.

CHAIRMAN WALLIS: So all this is out there waiting for response.

MS. CUBBAGE: In a number of cases, we have discussed the questions with GE and we haven't received answers in letter form.

CHAIRMAN WALLIS: And you're still reviewing test reports. You're going to run your own runs on TRACG and so on, so at the moment, we have no idea what are going to turn out to be major issues, if any. We have no idea. It's far too preliminary to sort of say you have identified certain key issues.

MS. CUBBAGE: That's right.

MR. RAZZAQUE: I would think the issues can be in the testing area, scaling-testing area or the TRACG.

CHAIRMAN WALLIS: But it seems to be too early for the ACRS to focus on anything.

MR. RAZZAQUE: Anything, including the testing.

CHAIRMAN WALLIS: All we get is a general impression of activity.

MR. RAZZAQUE: That's true. And one of -- my understanding is, one of the end product that GE is interested from NRC, end- product after the pre-application is not just the code -- approval of the TRACG code, they also want that we tell that no more testing is needed. Correct?

MS. CUBBAGE: Basically, it would be a determination on the acceptability of the test program for certification.

MR. RAZZAQUE: So that would be the outcome of the testing review, scaling testing, that those were done adequately and no more tests are needed. So it's too early to say -- come to that conclusion, that's for sure. Absolutely. That's basically it.

MS. CUBBAGE: If there are no more questions, we can move on to the Office of Research.

CHAIRMAN WALLIS: What I learned from GE was that they seem to have a lot of stuff. And probably they have enough stuff for you to review it. There's enough stuff there, enough substance that it's worthy of review.

MR. RAZZAQUE: Right. When the responses come --

CHAIRMAN WALLIS: I have no impression yet from your work whether or not it's good stuff, and adequate stuff.

MR. RAZZAQUE: At this stage, it is the questions we have raised.

CHAIRMAN WALLIS: All right.

MR. RAZZAQUE: Until we hear responses from them, I don't think we made any conclusion at this point.

CHAIRMAN WALLIS: Okay.

MR. BANERJEE: Have you identified any major hole in the testing or tests at the moment, just looking at this huge amount of stuff which is around, is there anything that you think --

MR. RAZZAQUE: My gut feeling is no. Basically, probably you're asking for gut feeling.

MR. BANERJEE: Gut feeling, yeah. That's it.

MR. RAZZAQUE: No.

CHAIRMAN WALLIS: So you go through the motions of hundreds of RAIs, and there's nothing substantial in it?

MR. RAZZAQUE: Yeah, we haven't gone through it. Yeah, we haven't gone through those information. First of all, the information is not back yet. The question is just going out. Tomorrow we're going to spend going through these RAIs, whether they understand what we are asking for.

CHAIRMAN WALLIS: I just wonder if the RAIs aren't becoming too trivialized. Really, you ought to be able to focus on some things that really matter. You've got hundreds of them. How do we know which of them matter? How do they know which of them matter? Maybe there needs to be a prioritization or something of these RAIs.

MR. RAZZAQUE: We write significant RAIs. We do some prioritization.

MS. CUBBAGE: Well, I think today Muhhamad has tried to highlight some of the more significant in his mind questions.

MR. RAZZAQUE: Yeah.

MS. CUBBAGE: And, you know, I don't think he's trying to say that GE won't be able to respond to these questions. We just haven't been able to review the responses at this time.

MR. RAZZAQUE: Right. But sake of completeness, at least, they have to respond to these kind of questions. As I said, from the up front, it looks like there is no major holes or gaps, unless the response we get is completely out of the way and that we didn't expect.

CHAIRMAN WALLIS: Okay.

MS. CUBBAGE: Okay?

CHAIRMAN WALLIS: Move on.

MS. CUBBAGE: Joe.

CHAIRMAN WALLIS: Thank you very much.

MR. STAUDEMEIER: I'm Joe Staudemeier from the Office of Research. I'm going to give you an overview of the things we're working on in Research related to ESBWR.

The focus of our Confirmatory Research Program is to provide assessed independent analysis tools to NRR to support the ESBWR design certification, and primarily, its codes that we're going to be providing to NRR that'll be qualified to work and analyze ESBWR. We're also providing assistance to NRR for the ESBWR pre- application review in support of the code, and testing and scaling review.

Right now in the pre-application stage, we're providing support and reviewing the scaling testing and TAPD PARC documents. Many of the RAIs have come from the Office of Research reviewers, and we're also demonstrating a proof of principle on developing a coupling between TRACE and CONTAIN, so that they can analyze some ESBWR accident scenarios.

MR. KRESS: Does GE have to pay for that, or is that something that --

MR. STAUDEMEIER: No, that infrastructure, considered infrastructure work. They have to pay for the review of the documents. We're acting essentially like a contractor, and that's directly fee billable, but code development is considered infrastructure work.

The work that will apply to the design

certification stage is some TRACE code development that I'll go over on later slides. Code assessment to show that it's applicable to the accidents that they want to use it for.

We're going to do a -- right now, actually, we're doing a PUMA ESBWR Scaling Study, which will look at how well PUMA can seemingly -- or how well PUMA is as a scale facility for ESBWR testing. We're going to be doing some PUMA testing and some --

CHAIRMAN WALLIS: All this is in the future, and we have not -- you have not yet done the PUMA Scaling study?

MR. STAUDEMEIER: That's going on right now.

CHAIRMAN WALLIS: Have not yet shown that PUMA is a suitable facility for doing this testing, have not done any testing. So all this is sort of way in the future.

MR. STAUDEMEIER: Not too far off in the future.

CHAIRMAN WALLIS: But it may turn out to be not a very good idea to do testing at PUMA.

MR. STAUDEMEIER: And if we -- if the scaling study says that, that its either not a good idea, or that area extensive modifications are made, what we'll have to do is look at the results of the scaling study.

CHAIRMAN WALLIS: Are you doing these tests because you think the GE tests are inadequate? If the PUMA test is a poor version of a GE test, there's no sense in doing it, is there? If it's a better test in some way --

MR. STAUDEMEIER: I mean, we believe it's a better test in several ways, but --

CHAIRMAN WALLIS: So you're going to show that, or you expect to be able to show that.

MR. STAUDEMEIER: We expect to be able to show that, and it also gives us some independent data of the code assessment.

MR. BANERJEE: Were you involved in the PANDA data? I mean, was NRC a participant in those tests?

MR. STAUDEMEIER: No.

CHAIRMAN WALLIS: I thought they said that you were.

MS. CUBBAGE: In a reviewer standpoint, not as a participant.

MR. STAUDEMEIER: Yeah. Previous PANDA tests, I think there were NRC observers at some of the tests, and I think they reviewed the QA Program, and probably provided RAIs on the test, but I wasn't involved in reviewing the PANDA tests back then, so I'm not sure what the total involvement was.

MR. RAO: Yes. The NRC also participated in applying test matrix, and reviewing the test, and providing oversight.

MR. BANERJEE: That was in the M-series. Right? Also, in the P-Series?

MR. STAUDEMEIER: Only M-Series.

MR. BANERJEE: Only M-Series.

MR. STAUDEMEIER: Yeah. P-Series came after the SBWR review.

CHAIRMAN WALLIS: PUMA doesn't satisfy the scaling criteria set out by GE, does it?

MR. STAUDEMEIER: I don't know what --

CHAIRMAN WALLIS: I don't think it does. When they say you've got to duplicate links and things, and I don't think it duplicates links very well.

MR. STAUDEMEIER: Well, it's not a full high scale facility. Yeah, that's --

CHAIRMAN WALLIS: So you're not going to be well scaled according to their PI-Groups.

MR. STAUDEMEIER: Well, I don't think

scaling -- I don't think only full height facilities can be well scaled facilities. It depends on what phenomena you're looking at. And, for instance, PUMA, since it's quarter height and twice the power, time runs twice as fast in PUMA.

CHAIRMAN WALLIS: Particularly for gravitational driven things. You need to -- usually you need to have the right height.

MR. KRESS: It's height versus --

CHAIRMAN WALLIS: Height versus resistance and everything, and scaling sort of drives you to full height.

MR. STAUDEMEIER: Well, if you want time preserved it's full height.

MR. BANERJEE: Well, it's a major problem, and you'd have to justify a reduced height facility very, very carefully.

MR. STAUDEMEIER: Things become more sensitive because DPs become scaled by DP over 4, essentially.

MR. BANERJEE: It's hell, actually. So we'll see this --

MR. STAUDEMEIER: It's been done before. OSU was a problem that was sensitive like that.

MR. BANERJEE: It's very sensitive, and

for a large number of the tests, they're not very useful. I mean, for long term cooling, it's a different matter. This was shown in the AP600 study, as well. It's documented.

MR. STAUDEMEIER: But you'll have access to the scaling study, and access to a presentation on it in the future, if you want to.

MR. SCHROCK: What is the status of your documentation on TRACE?

MR. STAUDEMEIER: TRACE documentation is still in draft. I think everything is still pretty much in draft form. It's fairly complete because it's based mainly on TRAC documentation. Some of the things aren't documented at all, like features that have been added to be able to run RELAP decks, and the code architecture isn't fully documented. The programmer's manual isn't current. But in terms of theory manual, like models and correlations, that's fairly accurate. Input manual is accurate, even though it's in draft form.

MR. SCHROCK: I can remember four or five years ago, discussions developing on TRACM, and the advice given would be useful if ACRS could see some documentation on what's happening here, so it can advise while it's happening, rather than when it's accomplished. Then we got a batch of documentation that look like recycled dose elements reports. That's all I've ever seen. Is there more than that?

MR. STAUDEMEIER: There is some fresh documentation. I'd say a lot of it is still based on Los Alamos reports, but I think you're probably going to be getting to review that sometime in the near future, the documentation. I'm not sure what the latest schedule is to finalize documentation, but it's certainly not before the end of this year.

CHAIRMAN WALLIS: So this is not a fee billable thing. This whole PUMA thing is public money.

MR. STAUDEMEIER: Yes. And I think the distinction that makes it fee billable or not is if NRR said they needed this test facility to certify the ESBWR design, it would be fee billable, but that's not the case.

CHAIRMAN WALLIS: I'm just wondering if this is a well thought out thing to do, to run PUMA. I don't know, because we haven't had a chance to review it. I just wonder if at this stage it's the right thing to do. There's all this other data out there that GE has taken. I would think you'd want to get the most out of that first, and see if there are any gaps in it. Is PUMA filling some identified gaps in the database?

MR. STAUDEMEIER: I don't think there's been enough review of all the data yet to determine that. There are some preliminary tests --

CHAIRMAN WALLIS: Maybe it's an attempt to keep PUMA alive somehow.

MR. STAUDEMEIER: I'm not the person to ask that.

CHAIRMAN WALLIS: Maybe in our research report we can look at this carefully.

MR. STAUDEMEIER: That's, I guess -- it may be something you want to review, is the PUMA program and what it is.

CHAIRMAN WALLIS: I just don't want us to have to come down in a negative way about it. I just want to be sure that you know what you're doing. I don't want to be negative about it, after we've had enough to know, because at the moment, I just feel uncertain.

MR. STAUDEMEIER: Okay. Well, I'll go over a little bit about preliminary testing program, and the scaling that's going on.

CHAIRMAN WALLIS: I don't know if you need to do it now, but maybe -- go ahead. I'm sorry.

MR. STAUDEMEIER: And we're starting up some work on severe accident analysis. Right now we're just looking at developing MELCOR input and the actual analysis won't come for quite a while.

Okay. Right now we're providing technical assistance and review of the scaling testing in PIRT reports, and eventually we'll be providing a technical evaluation report on the documents that NRR will use in their safety evaluation.

CHAIRMAN WALLIS: This is all just beginning too?

MR. STAUDEMEIER: Actually, it began a few months ago. The RAIs are the first product of the review.

CHAIRMAN WALLIS: So ISL has identified some things that are worth following up?

MR. STAUDEMEIER: The ISL which is -- Marcos Ortiz is the person from ISL reviewing the information. Marino DiMarzo from Research, Jim Han from Research, and Dave Bessette from Research has all contributed RAIs on those documents. So the status of that is RAIs will be completed for testing reports in the near future. They are already complete for scaling and TAPD PIRT reports, and TERs are scheduled to be completed in the fall, presuming that GE answers all the RAIs by then, and we come to closure on issues.

The TRACE/CONTAIN coupling for ESBWR calculations, TRACE is capable of modeling the ESBWR reactor vessel and phenomena that go on in there. It's not adequate for modeling the ESBWR containment because of some reasons I'll get into it a little bit.

CHAIRMAN WALLIS: TRACE has not yet modeled the ESBWR vessel.

MR. STAUDEMEIER: There is a TRACE model of the ESBWR.

CHAIRMAN WALLIS: It has run?

MR. STAUDEMEIER: Yes. It'll run to steady-state. I don't know if it's been run to blow-down yet, but I'm not sure of the current status of that.

CHAIRMAN WALLIS: But you're asserting it's capable. That's a statement of faith, isn't it?

MR. STAUDEMEIER: Yeah. I mean, an ESBWR vessel will blow-down like a regular BWR vessel, and I know it can do a regular BWR vessel blow-down.

CHAIRMAN WALLIS: So it should be capable based on its past performance.

MR. STAUDEMEIER: Yes. Okay. We have CONTAIN which is capable of modeling ESBWR containment, because there was some work put into that factor in the SBWR review to give it modeling capabilities for SBWR. One of the things that's been done to TRAC to make it into TRACE is to build-in this coupling capability to other codes that we call the exterior communications interface. And it's a communications protocol between TRACE, and you can build it into other codes so that the other codes can request information from TRACE, and send information back to TRACE, so that they can run in a parallel mode.

And we've recently modified CONTAIN to support the ECI so that it can run coupled calculations of TRACE. We'll be modeling the ESBWR vessel in TRACE, and model the containment in CONTAIN. There is a CONTAIN model built, and the codes will run in parallel, and communicate through the ECI. And some preliminary calculations that are showing proof of principle have been run.

CHAIRMAN WALLIS: This is reasonably efficient and doesn't need an enormous amount of time while they're communicating to each other?

MR. STAUDEMEIER: The communication time is probably significant for the time it takes for a CONTAIN time slip. I mean, essentially you're running

CONTAIN for free, I think, compared to TRACE, the amount of computational time for time steps, because CONTAIN is just a small number of coupled ODEs. Whereas, the TRACE model has many volumes.

MR. POWERS: CONTAIN was going like a bat out of hell compared to TRACE.

MR. STAUDEMEIER: Yeah. Coupling points and modeling, but hopefully we'll get those things all worked out in the future, and we'll get something that runs reliably and stable. The time step control in CONTAIN is fairly primitive compared to TRACE, and we think that TRACE would be the limiting time step in the calculation, but it turns out CONTAIN is what's limiting the time step.

MR. BANERJEE: Is the coupling point mainly the break, or are there other --

MR. STAUDEMEIER: There's several coupling points. The break is one of them. SRVs going into the suppression pool. There's pressure coupling points at the top of the GDCS, so there's quite a number of them.

Okay. The TRACE code development going on, recently some work was completed to add the capability to model advanced BWR fuel designs to both TRACE and PARCS. PARCS is the 3-d kinetics code that also runs in a coupled mode with TRACE for doing coupled thermohydraulic reactor kinetics calculations.

CHAIRMAN WALLIS: These are lousy projectory things. I mean, the corners are almost invisible, unless there's something wrong with my eyes. I have to read the paper.

MS. CUBBAGE: I don't know if it's the font or if it's the projector.

CHAIRMAN WALLIS: Well, you've got to fix that somehow. It's gets dark and fuzzy in the corners, and brights and shiny in the middle. I don't know what it is, but it's lousy.

MR. POWERS: Getting cranky in your old age here?

CHAIRMAN WALLIS: I'm trying to compete with my colleague on my left.

(Laughter.)

MR. POWERS: Don't do that. He's a past master.

MR. STAUDEMEIER: Additionally, some things are going to be added to TRACE in the future that will allow it to better model coupled reactor containment problems, such as ESBWR. And the two main tasks that should help that out is to improve the steam air condensation modeling for the PCCS, ICS, and the --

CHAIRMAN WALLIS: So when is the NRR going to say that TRACG is okay for use with ESBWR? Isn't it before all this has happened?

MR. STAUDEMEIER: This isn't going to support the --

CHAIRMAN WALLIS: What is it supporting?

MR. STAUDEMEIER: The design certification reviews.

CHAIRMAN WALLIS: So you're looking way ahead.

MR. STAUDEMEIER: Right.

MR. LANDRY: Graham, Ralph Landry from NRR. The TRACG review is going to be completed before this is done, you're correct. At least that's our anticipation. The work that is being done with TRACE is in support of the design certification of the plant. We are doing some calculations using CONTAIN with TRACE currently, as part of our confirmatory calculations, but those are not what we are basing approval of TRACG on.

CHAIRMAN WALLIS: It would be rather embarrassing if you approve TRACG, and then these guys come up with different calculations a year from now which show that the whole approval was in question.

MR. LANDRY: That's always a possibility, but you have to be able to, at that point, show which code is actually correct then. And the way you do that is by assessment against test data. If the code is assessed against test data and shown to adequately represent the test data, then it's hard to discount it.

MR. SCHROCK: You're starting with the assumption that one of them is correct.

(Laughter.)

MR. LANDRY: Thank you, Virgil.

CHAIRMAN WALLIS: Also, that the test data is correct.

MR. SCHROCK: Or relevant.

CHAIRMAN WALLIS: Or well scaled.

MR. STAUDEMEIER: The tube condensation model is going to be based on some work Joe Kelly did back for actually SBWR, that was originally going to be implemented into RELAP-5, and never got implemented when the SBWR review was cut off, so the tube condensation work is in a fairly advanced state, even though it's just started. It's not like he's starting from scratch. There's been many of the correlations that have been developed already, and just need to be implemented into the code.

We also need to change the energy equation to an enthalpy-based formulation to improve energy conservation and flows across junctions with large pressure differences. The difference in scheme in TRAC right now with the energy equation, the work term, PV work term is not treated very well. And changing to the enthalpy formulation will give a correct treatment of that, and give the right energy deposition into the containment. We're keeping the solution variables in the code the same. It's just changing the equation that's being sought.

The containment-related code modifications have just started. The condensation work is scheduled to be completed by the end of September, and the energy equation work should be completed by the end of January next year.

MR. BANERJEE: Let me ask you a question. A lot of this chimney stuff that the way TRACG is handling it is backing it out of the drift flux-type formulation, which is what anybody would do. How is this handled in TRACE, the same way?

MR. STAUDEMEIER: Well, TRACE has a different correlations package. It's actually -- TRACB has a correlations package that's very similar to GE's.

MR. BANERJEE: Right.

MR. STAUDEMEIER: The TRACE correlations package currently is based on the TRAC correlations package, so the DRAG correlations have a different basis. I'm not sure -- they not based on drift flux correlations though.

MR. BANERJEE: That's what I thought, so how do you expect to handle level swell, because it's not easy to do with the sort of fluid model unless you back it out of the drift flux correlation.

MR. STAUDEMEIER: Well, we'll do a code assessment against some level swell experiments and see how well it predicts it.

MR. BANERJEE: Okay. That hasn't been done yet.

MR. STAUDEMEIER: I think there's been some preliminary assessment done. I'm not sure what the results of that were, but that will be looked at and see if it's adequate or not.

MR. BANERJEE: Right.

MR. STAUDEMEIER: I guess one option is to put an option in to use the TRAC BWR correlations package in TRACE.

MR. BANERJEE: Right. It's notoriously difficult to get it right if you don't back it out of drift flux. That's the reason they went that way.

MR. STAUDEMEIER: Well, I guess the only data really available is steady state data, and for that, the drift flux is just as good as --

MR. BANERJEE: Yeah, better.

MR. STAUDEMEIER: Okay. The TRACE code assessment, right here I just have documented some of the ESBWR-specific tests that we're going to be looking at. But in addition to that, there will be basic void fraction assessment and things like level swell assessment that are also important calculations.

For the integral tests, we're going to look at PUMA and PANDA data. The PANDA series is the latest PANDA series, ESBWR PANDA series. We're developing an input deck from information that came out of an international standard problem that was performed with some of the PANDA P-Series data.

MR. POWERS: Which problem was that?

MR. STAUDEMEIER: I'm not sure what the number is.

MR. POWERS: In the 40s or the 30s?

MR. STAUDEMEIER: Forties again, but we can get you a copy of the documentation, if you're interested.

MR. POWERS: It would be useful.

MR. STAUDEMEIER: And the PUMA data, we're going to be looking at the data that was already taken back in the SBWR days, so that's existing. Purdue has developed a TRACE stand-alone model that everything is modeled in TRACE and is run through a main steam line break calculation. There are some code deficiencies that were identified, but it made it through to 7,000 seconds under a main steam line break calculation, which is equivalent to 14,000 seconds of reactor time essentially, so it made it pretty far into the transient.

In terms of PUMA, there's some small modifications to PUMA that are being made right now. The GDCS is going to be connect -- is in the process of being connected to the wetwell, and it actually may already be connected as we speak. And some integral tests are going to be run to see what the differences just from that change between GDCS connected to the drywell, and GDCS connected to the wetwell, to see that the code can predict the differences between those two different configurations.

There are some separate effects tests that will also be run in PUMA, which are some condensation tests that have been identified for tube condensation, and also condensation in the wetwell, and that will be used to assess the condensation models that Joe Kelly is going to be developing for TRACE. In addition to the PUMA data, we'll also look at some other condensation tests.

The status of that is the PUMA stand-alone TRACE model has been run, code deficiencies have been identified, and we'll look at resolving them in the near future.

CHAIRMAN WALLIS: Was it run successfully?

MR. STAUDEMEIER: Well, it ran successfully without crashing, I guess if that's what you term "success". Some of the parameters that have been predicted were not predicted so well. They predicted GDCS injection to start too early. The GDCS flow rate, they compared fairly well. Some things compared fairly well, some things didn't compare that well, which the new condensation models I think will greatly improve code results.

MR. BANERJEE: Did it get the pressures right?

MR. STAUDEMEIER: No. It over-predicted the drywell pressure, and under-predicted the wetwell pressure.

CHAIRMAN WALLIS: So you're now going to tune TRACE to the PUMA test?

MR. STAUDEMEIER: No, it's not going to be tuned. I mean, the condensation models are going to go independently of the PUMA tests. They'll be run after the condensation models are implemented, but we don't tune or adjust code results based on integral test data.

Okay. There's a PANDA TRACE model that's being developed right now in-house based on the information from the International Standard Problem. And there will also be coupled TRACE/CONTAIN decks for both PUMA and PANDA that are going to be developed to show that the coupling works, and that the coupled calculations are giving good results.

Okay. Right now there's a PUMA ESBWR scaling study going on out at Purdue for --

CHAIRMAN WALLIS: How long does TRACE take to run compared with TRACG to solve the same problem?

MR. STAUDEMEIER: I don't know how long TRACG takes to run on a given platform. I'd need to know how long it takes to run -- Shanlai probably has more experience.

MR. LU: The TRACG to run 72 hours, main steam line break case. It takes about four days on RVMS machine. But you tell transit in 72 hours. It's very good in terms of running the TRACG. Right before the GDCS line break, look like it's very short. It's a couple of hours, so that's TRACG code. TRACE code right now in steady state, we reach very good steady state code, 120 seconds right now we ran.

CHAIRMAN WALLIS: Steady state is really of no interest.

MR. LU: Right. Well, that -- I'm talking about the 120 seconds into the main steam line LOCA case. It takes about 2 hours. Okay. But right now, the --

CHAIRMAN WALLIS: It's comparable with TRACG.

MR. LU: It's hard to compare because we are running on a different platform.

CHAIRMAN WALLIS: You're running on Octave platform?

MR. LU: The TRACE and the CONTAIN is running on PCs, Pentium 4 and a bigger CPU. Whether the NRR VMS is --

MR. STAUDEMEIER: Yeah, the machines that TRACE runs on are quite a bit faster than the machine that they have TRACG running on because that's quite an old machine.

I believe the PUMA calculation to run out to 7,000 seconds took on the order of one and a half days to two days, and that was on some kind of Pentium 4 that's about two gigahertz. But a lot of that time, the code was bogged down with condensation oscillations because of the bad condensation model in the code. And I think the run time should improve greatly when the condensation model gets fixed.

CHAIRMAN WALLIS: So 59 runs would take half a year?

MR. STAUDEMEIER: No, not -- I mean, we have quite a few machines that we could run them on at the same time.

(Laughter.)

CHAIRMAN WALLIS: Take 59 machines, right?

MR. ROSENTHAL: Excuse me. This is Jack Rosenthal, Branch Chief in SMSMP. You know, it's -- we will be releasing production, a release version of TRACE in the fall. And right now what you're doing is you're comparing times on a beta version of the code. And as we fix the physics in the code, we expect to gain some run time speed, so it's just not a good comparison. Measure us in the fall.

MR. STAUDEMEIER: Okay.

CHAIRMAN WALLIS: So this is a simplified BWR. There's nothing simplified about modeling it with the code. It's still just as complicated, and takes as long.

MR. STAUDEMEIER: Probably longer right now because the code was never really made to do all the condensation at low pressure with non-condensibles that it needs to do for the ESBWR model.

Okay. The scaling study, PUMA was designed to a scaled SBWR integral test facility, and it's scaled pretty well for that using inching scaling. The ESBWR containment differs from the SBWR containment topologically. The GDCS is now in the wetwell, previously it was in the drywell. And in the non-dimensional scaling ratios, like power to volume and things like that are different things.

CHAIRMAN WALLIS: So the scaling basis is very much like the APEX scaling basis, isn't it? APEX is to AP600 about what PUMA is to SBWR.

MR. STAUDEMEIER: Yeah. Both core height, both facilities were designed to look at long-term cooling phase of the accident. APEX wasn't full pressure. It was a reduced pressure. PUMA is full pressure, and it's designed to pick up the transient partway into it. It picks up from the late blow-down phase, but from then on, it's a full pressure facility. And time runs twice as fast, I think, in both facilities. So the scaling study should be completed by the end of August. We'll evaluate the scaling distortions that exist in the present facility. If the scaling distortions aren't great, then maybe the tests we're running now with just a limited modification connecting the GDCS to the wetwell instead of the drywell will be data that's good enough.

If there's great scaling distortions, we'd have to look at the modifications necessary to make PUMA a well scaled ESBWR test facility, and decide whether it's worth it to make those modifications and do additional testing at that time. That decision will be coming sometime in the fall, on what modifications would be made, what impact they would have on the tests, and whether to make --

CHAIRMAN WALLIS: So this facility and this plan was not designed to answer specific questions. It seems to be just sort of a catch-all, where you want it and then you use it in ways yet to be determined.

MR. STAUDEMEIER: Well, it's to look at integral system response and provide data for the codes that's representative of things that go on the SBWR.

CHAIRMAN WALLIS: It's a very general kind of purpose.

MR. STAUDEMEIER: Right. It's more --

CHAIRMAN WALLIS: In other words, if you're focusing on certain key questions which have been identified --

MR. STAUDEMEIER: Well, passive heat removal and system interactions between the various places due to passive heat removal, I guess is the main thing that the facility is looking at to make sure there is no, I guess, surprises that pop up which -- and also, to look at the whole transient from near the beginning all the way through long-term cooling, which it's -- I guess that's the one thing that makes it unique compared to the other facilities, is it covers a longer range of time in the accident.

Okay. PUMA confirmatory testing. Currently right now, the old PUMA test data is being used for TRACE/CONTAIN code assessment. Modifications are underway to connect the GDCS change to the wetwell, and the same tests will be run in that configuration to examine the differences in the facility response between the two different configurations, and see that the code can predict the difference in the two different configurations. Other than the connections, the tests will be run in as identical a manner as possible.

As I said, additional modifications may be needed or identified based on the outcome of the scaling study, which should be available at the end of August. And also, the separate effects tests will be used to study tube and suppression pool condensation. It will be used as additional data for code assessment of the condensation models that Joe Kelly is going to be putting in the code.

The integral testing with this limited modification is planned to start in August. Separate effects testing is planned to start in September, and a decision on additional facility modifications and testing will be made in the fall after we get the results of the scaling study, and do some sort of cost benefit study on the outcome of that.

MR. ROSENTHAL: Do you expect --

MR. BANERJEE: Before we get on to --

MR. ROSENTHAL: Oh, I'm sorry.

MR. BANERJEE: I was just going to ask you, the SBWR and PUMA were scaled, if you agree with the scaling methodology they were scaled. And then the ESBWR is just double the power or something roughly, and volume. So why do you expect such a big difference in the scaling between the two?

MR. STAUDEMEIER: Well, the volumes aren't scale. Like you double the power, but the drywell volume isn't doubled, or the wetwell volume isn't doubled. So actually, I think the first look at it looks like you would have to remove volume in the wetwell from PUMA, which would mean putting maybe -- I think one idea was putting hollow steel balls in there or something to take up some of the volume.

MR. BANERJEE: Yeah, I remember now, because the PANDA P-Series was different from the M-Series. The volumes were all adjusted, so that's what -- that's the main difference.

MR. STAUDEMEIER: Right.

MR. BANERJEE: Okay.

MR. ROSENTHAL: Before we get into just the one slide on severe accident, if we try to look into the future some months or a year or so, one could anticipate that the real issues, or that there will be issues on the SBWR concerning stability, neutron thermohydraulic stability, and ATWS and stability behavior during the course of an ATWS. And in anticipation of that, what you want is a code that couples neutronics and thermohydraulics in the containment, and so that's the PARCS, TRACE/CONTAIN coupling, will give us the tool to independently assess. I anticipate there'll be questions a year from now.

Similarly, we did do some work with PUMA and we're about to publish results of some stability tests where, you know, they're electrically heated rods, and we changed the heat flux just using controllers, but did get some stability tests which allow us to benchmark the code. And so it is reasonable to anticipate that PUMA may play a role a year from now in answering questions concerning stability, so stability during the course of an ATWS is of particular interest to me. But, of course, that's what I've just said, trying to anticipate the future is somewhat speculative, and I think that Joe is absolutely right, you know, in saying we'll do the scaling analysis. We'll do the analysis, and if it makes sense, we'll run the facility. And if it doesn't make sense, we won't do it.

MR. STAUDEMEIER: Stability experiments in PUMA are the type of experiments that we looked at in pre-EPRI, which is the flashing instability, with the flashing in the chimney region. It's not density wave instabilities.

CHAIRMAN WALLIS: That's dependent on the balance between gravity and pressure, so how do you do this in a system which isn't full height? Do you run it at --

MR. STAUDEMEIER: Well, you have to look at your scaling groups and what they tell you about -- excuse me?

CHAIRMAN WALLIS: Run it at pressure below the pressure that's actually anticipated in the SBWR?

MR. STAUDEMEIER: Well, it'll flash at -- I mean, the elevation where it flashes will be lower. So as I said, the Dps are scaled by a quarter, so that this pressure is full scale, but Dps are scaled by quarter height, so the --

CHAIRMAN WALLIS: Well, I don't know if that works out.

MR. STAUDEMEIER: You have to look at the scaling --

MR. BANERJEE: Yeah. If you want to do that, the modification needed is make it full height.

MR. STAUDEMEIER: Right. But I mean, you get non-dimensional equations in scaling groups, and you can compare that to the --

MR. BANERJEE: No. I think Graham's question is the one that we all have, is as they were saying, you've got this column of water right at the top that starts to boil. And the reason it starts to boil is, of course, that the suppressed boiling due to this gravity head.

MR. STAUDEMEIER: Right.

MR. BANERJEE: And then it goes out of boiling, and it comes back into boiling. And, you know, how do you do it without that gravity head? I don't understand that.

CHAIRMAN WALLIS: You have to run it at lower than design pressure.

MR. BANERJEE: You'd have to do some major change, like Graham is saying.

CHAIRMAN WALLIS: Then you've changed all the properties.

MR. RANSOM: I've never quite understood the desire to, you know, try and maintain exact similarity, which is never done, you know, in any of these test facilities. But in terms of gravity, this sticking to full height it seems to me is -- may not be, you know, a necessary criterion. And in fact, I've never understood why you can't use the codes which embody all the physics of the hydrostatic head, and the flashing effects, and compare full scale with limited scale. And basically, we did do that in PUMA. And, you know, within limited scaling. I mean, if you go to extremes, of course, you would -- some of the phenomena might disappear. But examine the similarity using the codes. It doesn't necessarily mean they're exactly right, but you can go back and examine how well does that kind of facility simulate the behavior by comparing it with say a full-scale model of the plant. And I think that's been quite successful in that case. And you really need to look at it on that basis. You have to look at a code model for the test facility, and a code model for the full-scale plant, and then compare those two to see are the same phenomena present.

MR. BANERJEE: Sure. I mean, you can get the same phenomena. Just heat up the core more and you'll get boiling at the top. I mean, it's always possible.

MR. STAUDEMEIER: I guess one thing -- I mean, you come up with a stability boundary based on non-dimensional equations, and maybe you run your code to see if it predicts the same stability boundary that the experiment does, and that gives you some additional information of whether it can predict the stability boundary in the full height.

MR. BANERJEE: The problem with Vic's argument is really that the code should be a scaling tool. And everything you do with the code, every experiment you do is, therefore, relevant. It doesn't really matter. That's true if the code converges in a mathematical sense. Most of these codes, however, depend on fancy nodalization to make them come close to reality. And the nodalization becomes a part of the problem, and that's part of the CSAU methodology. We understood that these codes would not converge when we set that up.

MR. SCHROCK: I don't believe in that.

MR. BANERJEE: Well, but that's exactly what happened.

MR. SCHROCK: I mean, you're making approximations that are far greater in all the models.

MR. BANERJEE: You always change answers. I mean, you saw that with the way the lower plenum is nodalized in AP --

MR. SCHROCK: But those are for different reasons. Those don't have anything to do with --

MR. BANERJEE: No, no, no. I'm saying they don't --

MR. SCHROCK: Or converging in that sense.

MR. BANERJEE: You change the nodalization, you change the answers. Unfortunately, that's the state of the art right now. And, therefore -- I mean, you want the experiments to be as nearly representative of reality as you can be, because you want to nodalize them roughly the way you're going to do it with the full plant.

MR. SCHROCK: Well, you can simply test them by the model of the experiment. And, you know, these things have to have some similarity between the actual plant and the experiment in terms of lower plenum, core locations, where the containment is located. But generally, the experimentalist tries to do that.

CHAIRMAN WALLIS: There's a sequence of events though. It may be that if you have this column of water suppressing the flashing that you won't get flashing. But then if you have a much shorter column of water in another test, you will get flashing. You're getting something in one test that wasn't there in the other test.

MR. STAUDEMEIER: Well, the flashing happens at a higher elevation. The fluids don't keep going up. At some point, it's going to flash.

CHAIRMAN WALLIS: The same pressure -- the way it progresses depend on this hydrostatic head, so something is going to be different about that.

MR. RANSOM: Well, the distribution will be different within the core. That's true, but in general though, you will -- if it's a boiling situation you will not see no flashing in one case, and some in the other. I mean, and yes, appear in one and not in the other.

CHAIRMAN WALLIS: But if you try to scale flashing you'll find that the elevation things matter.

MR. RANSOM: I think it would be worthwhile to look at some of these results that have been obtained for, you know, the different scales, and then comparing the two.

CHAIRMAN WALLIS: Well, presumably flashing is one of the scaling parameters, and this PUMA scaling study is --

MR. STAUDEMEIER: Yes. The report is in draft form. It should be finalized pretty soon, and you can get a copy of it.

CHAIRMAN WALLIS: Did they convince you that everything is all right?

MR. STAUDEMEIER: I haven't read it yet, so I don't know.

MR. BANERJEE: Well, Joe, as you know, scaling for different accidents is very different, whether you do it for a large break LOCA, small break LOCA, stability or whatever. So if stability is going to be one of the most important things you're looking at, then a scaling study has to be, you know, directed in that direction specifically.

MR. STAUDEMEIER: And it is --

MR. BANERJEE: Because it will be very different for a large break LOCA or a small break LOCA, or something.

MR. STAUDEMEIER: Yeah. There was scaling analysis performed specifically for the stability experiments.

MR. BANERJEE: Right.

MR. STAUDEMEIER: And that will be in the final report document.

MR. POWERS: Let me just interject that the way I understand, and I'm also extremely sympathetic with Vic's point of view on this. When you put together a facility, any experimental facility, you're not perfectly simulating anything. And if it so extraordinarily sensitive to one parameter, that is the height, that you cannot in any way model it in some approximate sense, it seems to me, that it hopeless to build the plant. Because when it gets fabricated, it is not going to be exactly the same height as planned.

MR. BANERJEE: It doesn't have to be exactly, but it shouldn't be one-quarter either.

There's a big difference.

MR. POWERS: Well, it's a little bit of a joke about the woman in the bar and the million dollar offer here. We know what you are, we're just arguing over price here.

(Laughter.)

MR. BANERJEE: A question of degree, I think.

MR. KRESS: I don't think we should prejudge this issue until we see the scaling analysis. I think it's entirely possible to have a facility like PUMA look at the flashing instability. You may have to change some other parameters, such as the inlet subcooling or the inlet heating or something like that. I think you can look at it. I'd be anxious to see the scaling first.

MR. POWERS: The larger issue, it seems to me, Tom, is that we invent these incredible complex and detailed computer codes, but when it comes to designing our tests, we go back to very approximate back of the envelope calculations. It's surprising that we don't make greater use of the codes themselves.

MR. KRESS: To do the scaling analysis. Yeah, you could very well use it, adjust these parameters to see whether or not you get --

CHAIRMAN WALLIS: I think that's a very good point. Before I would put a lot of money into a quarter-scale experiment, I would want to run TRAC, TRACE or something to show that I'm going to find the kind of phenomena that I'm looking for, and there isn't something which is affected by having it a quarter.

MR. STAUDEMEIER: Yeah. I mean, I think that will be done.

CHAIRMAN WALLIS: I missed something or introduced something which wasn't there in the full height.

MR. STAUDEMEIER: Yeah. In the PUMA design, I think RELAP-5 was used to --

MR. RANSOM: Right. In fact, even in the proposal we did that, you know, and showed that the same phenomena were present or predicted to be present in the sub-scale situation, and satisfied ourselves that that was a reasonable approach. And I think in the end, it really turned out that way.

MR. STAUDEMEIER: I'd also like to add that it's interesting what a difference the head of the subcommittee can make, because we're now going to hit Canton with some of the subcommittee. He is absolutely against running something like RELAP-5 end helping to do your scaling and work things out, so it's a matter of opinion, I think, in some cases.

MR. BANERJEE: Well, it's sort of a chicken and egg problem. It's an iterative process because if the code can't handle say oscillations or something, as you remember at that time, there was a problem because in the core uncovering phase, the codes would go into these enormous oscillations because it would slip at low pressure. So how could you use the code to do any scaling analysis?

MR. STAUDEMEIER: Yeah.

MR. BANERJEE: And Ivan was absolutely right.

MR. STAUDEMEIER: Yeah, you have to use good judgment in how you --

CHAIRMAN WALLIS: Well, remember AP600. We had this business of the fangs, the CMTS filled up with water.

MR. STAUDEMEIER: Right.

CHAIRMAN WALLIS: And then when you went to the full-scale, there was enough gravitational head so this never happened.

MR. STAUDEMEIER: That's not true exactly.

CHAIRMAN WALLIS: So it was a phenomenon

which changed completely when you went from small scale to --

MR. STAUDEMEIER: What happened in full height RELAP-5 calculations --

CHAIRMAN WALLIS: You couldn't possibly suck the waters up that far because there was so much gravitational head.

MR. STAUDEMEIER: It depended on the break, actually. For that one break, it couldn't happen, but there were other breaks where it actually could happen, and did happen in RELAP-5 calculations. It was a limited viewpoint, I think given at the time, that it could only happen in --

CHAIRMAN WALLIS: I see. Okay. Well, we should probably move on.

MR. STAUDEMEIER: Okay. For severe accident analysis, there's a MELCOR model that's under development. Look at in-vessel melt retention and other severe accident management strategies --

MR. KRESS: Has that been put forth as an accident management strategy by GE?

MR. STAUDEMEIER: I think unofficially it's been put forward. I don't think there's any official documents yet that say that.

MR. KRESS: Well, the only database I know is for PWR, so we don't have this forest of control rods coming up there. I don't know how you deal with that in terms of cooling on the outside of the vessel.

MR. STAUDEMEIER: Yeah. So as I said, that the calculations will be starting later on, once we get more of, I guess, some official information from GE on what needs to be analyzed. And also, the severe accident calculations will be supporting any PRA studies that go on for this plant.

MR. POWERS: It matters not on your heat transfer. I mean, there's some cooling chemistry that will take it --

MR. KRESS: The chemistry will take care of it for us.

MR. POWERS: We won't have to worry about it.

MR. ROSENTHAL: I think that the -- actually, we had a Lesson Learned from AP1000, where we did a lot of early thermohydraulic work, and then had to play catch-up in the severe accident arena. So we got a little bit smarter now with ESBWR, and said okay, the thermohydraulic work is obviously starting far in advance of lots of other disciplines that exist in NRR, for example. You're hearing -- as you observed, you're only hearing a small piece of all the kinds of review that would be done, but we recognize that we should start building a MELCOR deck now so that we'd be able to answer the questions to support the PRA review, rather than waiting a year from now. And that's all we're really trying to do, is get a start on what we know will be important.

MR. KRESS: Did the GE PRA use MAP?

MR. POWERS: Shows sound good thinking there.

MR. STAUDEMEIER: I also think they may have a MELCOR model for GE. And I'm not sure what the status of that is, and that we may be getting a copy of it.

MR. POWERS: More interesting than in-vessel retention is going to be accident management strategies to control gaseous iodine.

MR. STAUDEMEIER: Okay. The summary of what we're doing is --

MR. POWERS: I mean, the problem is you put them into -- the iodine into the suppression pool and yo continue to blow gas through it, you're going to pull it right back out again. I mean, it's a clear result out of NUREG 1150, as you continue to blow through the pools, you just pull the iodine right back out again.

MR. STAUDEMEIER: Okay. Most of the pre-application work is on schedule. We're a little bit behind on the testing review compared to where we wanted to be initially, and also the CONTAIN/TRACE coupling. I think we had hoped to have some full calculations done by this time, and have run into a few problems with that. But I think we're on schedule to resolve them fairly soon.

MR. SCHROCK: And that contained coupling to TRACE is related to the pre-application review?

MR. STAUDEMEIER: Well, I know NRR wants to use some of these calculations in their pre-application review as comparing -- doing some independent calculations to compare to the TRACG calculations.

MR. SCHROCK: Because when I read that, I thought they were referring to research commitments to assist NRR in the --

MR. STAUDEMEIER: Well, it's both of those. Yeah, both of those activities are for pre-application review, both the assistance in reviewing the topical reports, and also this TRACE/CONTAIN coupling.

And the additional activities in support of the design certification, they're not on quite as tight a schedule, and I think they should be done to support the design certification review. We should have code modifications and assessment done by that time, and have a fairly well-assessed code that NRR can use to do independent accident calculations.

And we may identify some additional activities in the future as GE submits additional information, such as ATWS and stability, that will require at least some additional code assessment to look and see that the code is okay for predicting that type of stuff. Any more questions?

CHAIRMAN WALLIS: Thank you very much. I'm trying to figure out what we need to do now. We've learned from GE and from RES and from NRR what the status of things is, and it seems premature for us to reach any conclusion whatsoever.

MS. CUBBAGE: Right. I think at this stage, we're not requesting a letter, but we'll be coming back in the fall with a draft safety evaluation report.

MR. KRESS: It's on the Full Committee agenda?

CHAIRMAN WALLIS: That's why I was asking. I think there's something on the Full Committee agenda.

MS. CUBBAGE: Oh, Full Committee, we're on the agenda this Thursday at 12:45.

MR. CARUSO: Do you expect anything out of that, or is that just a get to know you meeting?

MS. CUBBAGE: I believe it's just an informational brief.

MR. CARUSO: You don't expect a letter or a report, or anything like that.

MS. CUBBAGE: No, we don't.

MR. CARUSO: But the meeting on Thursday, that's not just going to be thermohydraulics. That's going to be ESBWR. Right?

MS. CUBBAGE: Well, it's a very short time window, and I believe GE is going to make a short presentation, and the staff is going to be available if the committee has any questions.

CHAIRMAN WALLIS: But it's not related to this Subcommittee Meeting, is it?

MS. CUBBAGE: Yes.

CHAIRMAN WALLIS: Is it something else?

MS. CUBBAGE: It is related to this.

CHAIRMAN WALLIS: It is?

MR. CARUSO: Is it? It's supposed to be thermohydraulics, or is just to be an overview of ESBWR. That was my understanding.

MS. CUBBAGE: Well, Atam, what do you have planned for Thursday?

MR. CARUSO: Well, do you guys want the meeting on Thursday? I know what you want. Excuse me. You're not going to get that.

MR. POWERS: They wish it was --

MR. CARUSO: What you expect.

MR. POWERS: Well, put a proposal in front of Tom. He might go for it.

MR. RAO: No. What we wanted was answers on these questions, do these look like there are any significant issues on the thing. But I think Graham has said that you don't have the information to pass any judgment on any of those issues, and so actually, maybe at this stage, it's premature to have a meeting actually.

CHAIRMAN WALLIS: Well, you're on the schedule and it's in the Federal Register.

MR. RAO: Yeah.

MR. CARUSO: You have to come and talk.

CHAIRMAN WALLIS: You have to do it.

MR. RAO: Yeah. We can talk. You know, we can talk.

(Laughter.)

MR. CARUSO: Well, you've been summoned to

Washington.

MR. RAO: It's after lunch, and so we don't want to make it such that it puts everyone to sleep.

CHAIRMAN WALLIS: How long do you have to talk? It's a long time, isn't it? It's a major thing.

MR. RAO: It's a two hour window there.

CHAIRMAN WALLIS: Yeah, that's my impression, it's a major thing.

MS. CUBBAGE: As you could tell from this morning, Atam will be able to fill that easily.

CHAIRMAN WALLIS: What are you going to do, try to compress what we heard today into these two hours? What's the intent?

MS. CUBBAGE: No, the staff won't be presenting. And I think you're basically just going to hear --

CHAIRMAN WALLIS: The staff won't be presenting at all.

MS. CUBBAGE: No.

MR. CARUSO: That's why I said, I thought this was just a get to know you type presentation.

CHAIRMAN WALLIS: Get to know you? We know you all. I think the Full Committee has seen you before too. And my advice would be to give more substance than the sort of sales pitch to the ESBWR, which we've heard before, which is very nice. But I would -- and I think what's impressive is that this is the results that you can always go something like 2 meters of collapsed water above the core no matter happens, and you've got -- you know, not sort of pushing some regulatory limit. You seem to be steering way clear of all the regulatory limits, and that's the sort of message I think you want to convey, a message of what you've learned from your testing, and why the testing is adequate to give confidence in your assertions.

MR. SCHROCK: Operators have a lot of time to sit around and think about that.

CHAIRMAN WALLIS: Right. That's what I would think you want to concentrate on, because the committee has seen this sort of thing, the overview of what this thing is, and why it's a good machine, and beautiful and everything. WE've heard all that before.

MR. KRESS: I think you may need to do a little of that.

CHAIRMAN WALLIS: You may do a little bit of that to orient them, but the main thing is what's the bottom line? This thing seems to be much more conservatively safe than all of the other things that are out there. Isn't that the message you want to put across?

MR. RAO: Yes.

CHAIRMAN WALLIS: And also, I think the adequacy of the test program is something you maybe need to put across.

MR. KRESS: Or at least bring up the point that that's the issue we're looking at.

MR. RAO: From our perspective it's, you know, the idea of trying to get closure on some of these issues is a very important consideration from our perspective.

MR. KRESS: I think you had a couple of slides that showed the extent of the test program that exists, which I think is very brilliant. I don't think we saw that before, and that's worth bringing out.

MR. POWERS: I think you can rest assured you will get a question on your material selection program.

MR. RAO: I think I've made that clear.

CHAIRMAN WALLIS: Is there enough for you to go on, to know what you want to present? It's your opportunity to get this ball rolling, it seems to me, before the Full Committee in a serious way.

MR. RAO: Okay. WE'll investigate that.

CHAIRMAN WALLIS: Now from what we've learned today, and I'd invite the Committee Members to give comments, do we want to have it on the record? I'm not sure we need to have the record, do we?

MR. CARUSO: I would suggest -- I mean, Graham, if you want to, you could talk about the fact that we had this meeting, and that they presented a lot of information about the test programs.

CHAIRMAN WALLIS: That's for Thursday.

MR. CARUSO: For Thursday.

CHAIRMAN WALLIS: Right. But I thought just to round-out today, I think we ought to have some frank opinions from the Committee Members. I'm not sure this needs to be on the record. Are we obligated to have it on the record?

MR. CARUSO: You mean the discussion right now?

CHAIRMAN WALLIS: Yes. If we have a sort of a caucus or discussion.

MR. CARUSO: It doesn't have to be.

CHAIRMAN WALLIS: Can we say goodbye to the record?

MR. CARUSO: I think so.

CHAIRMAN WALLIS: Okay. So please close the record now. Now we'll be off the record.

(Whereupon, the proceedings in the above-entitled matter went off the record at 6:34 p.m.)